RAPTOR RESEARCH

Volume 6. **Supplement Part A.** **1972**

SPECIAL CONFERENCE ON CAPTIVITY BREEDING OF RAPTORS–A REPORT

Sponsored by Raptor Research Foundation, Inc.
Held at Sioux Falls, South Dakota, U.S.A., November 22-23, 1971

Part A. Introduction.

by
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This conference was planned to assess the situation, to explore in depth the problems encountered, and to discuss possible future directions in raptor breeding. Formal talks or papers were limited; topics were organized into ten panel discussions on Biology and Management followed by a session on Evaluation and Planning. The program was intended to aid participants in breeding projects. Announcements were sent to all Raptor Research Foundation members and to all zoos in the United States and Canada.

The conference was held at the Holiday Inn in Sioux Falls, South Dakota. There were three sessions on Monday and two on Tuesday, November 22 and 23, 1971. Byron E. Harrell was the coordinator. Arrangements and aid at the meeting were provided by Donald V. Hunter, Jr., Dan O'Brien, Lee Eberly, and Joyce Harrell. Program suggestions were made by Tom Cade, James Enderson, Robert Berry, and Richard Fyfe. We are indebted to the ten panel chairmen who made arrangements for their own topics and to all of the panel members for their presentations. They are all listed below. The conference was tape recorded so a transcript could be prepared. Another conference in 1972 is anticipated.

The program was organized into the following panels.

1. Breeding Stock Inventory (Monday morning)–Donald V. Hunter, Jr., Chairman, Bob Hinckley, Roger Thacker, Bruce Wolhuter.

2. Housing and General Management (Monday morning)–Richard Fyfe, Chairman, James Enderson, Heinz Meng, James Weaver.

3. Health and Nutrition of Breeding Pairs (Monday morning)–William H. Halliwell, Chairman, David E. Allen, C. Wendell Carlson (his presentation on Monday afternoon), James McIntyre, Richard D. Porter.

4. Photoperiod Problems and Management (Tuesday afternoon)—Stanley Temple, Chairman (substituting for Tom J. Cade who could not attend).

5. Reproductive Endocrinology (Tuesday afternoon)—Erich Awender, Chairman, Timothy Lawson, James C. McIntyre, Stanley Temple.

6. Behavioral Consideration to Egg Laying (Tuesday afternoon)—R. Wayne Nelson, Chairman, Richard Fyfe, Frances Hamerstrom, Richard R. Olendorff, Dr. and Mrs. Noel Snyder (not present; contribution read by Nelson) [at the conclusion of this panel J. Gregory Thomas spoke about closed circuit television recorders, their use in observation, and the kinds of equipment available].

7. Artificial Insemination (Tuesday afternoon)—Robert Berry, Chairman, Frances Hamerstrom, Walter Morgan, Stanley Temple.

8. Incubation, Natural and Artificial (met with Panel 9 Tuesday morning)—Richard Olendorff, Chairman, Robert Berry, James Enderson, John Snelling, Stanley Temple.

9. Rearing, Parental, Foster, and Hand (met with Panel 8 Tuesday morning)—James Enderson, Chairman, Robert Berry, Richard Olendorff, John Snelling, Stanley Temple.

10. Health and Nutrition of Young (Tuesday afternoon)—Richard D. Porter, Chairman, William H. Halliwell.

11. Evaluation and Planning (Tuesday afternoon)—Donald V. Hunter, Jr., Chairman, Panel Chairmen and members.

A packet of 58 pages of material was given to all who had preregistered for the conference. Packet materials included:

1. Program (1 page).

2. Proceedings of a discussion Meeting on Captive Hawk Breeding (8 pages).

3. [6 pages; this was a copy of the MS of a paper in press in RRN; it was included without specific permission, but in response to the author's desire that his views get full consideration; he resented this inclusion, withdrew the paper from publication, and submitted it elsewhere; it is therefore omitted from this list.]

4. Galicz, G. and others, "Autumn Egg Production by Captive Peregrine Falcons" (3 pages, see *RRN* 5(6):150-151, 1972).

5. Breeding Project Questionnaire (1 page; this and the replies (6-12) are published in *Raptor Research* 6(1):16-18, 21-31 as B.P.I.E. Nos. 28-34).

6. Campbell, J. A. Report on Peregrine, Merlin, Red-tail (3 pages).

7. Allen, David. Report on White-tailed Sea Eagle (3 pages).

8. Meng, Heinz. Report on Peregrine (3 pages).

9. Hunter, Donald V. Report on Goshawk (1 page).

10. Hunter, Donald V. Report on Peregrine (1 page).

11. Hunter, Donald V. Report on Gyrfalcon (1 page).

12. Hunter, Donald V. Report on Red-tailed Hawk (1 page).

13. Thacker, Roger. "Estimations Relative to Birds of Prey in Captivity in the United States of America" (27 pages, *RRN* 5(5):108-122, 1972).

14. List of birds of prey currently held at Cornell—Tom J. Cade (1 page).

15. Snelling, John C. Abstract—"Artificial incubation, and temperature aspects of hand rearing downy raptors" (2 pages).
16. Snelling, John C. Abstract—"Artificial incubation of American Kestrel eggs" (1 page).
17. Enderson, James. Abstract—"Experiences with artificial incubation and hand-rearing of falcons" (1 page).
18. Olendorff, Richard. Abstract—"Hand-rearing of Buteos" (1 page).
19. Olendorff, Richard. Abstract—"Certificial incubation of Buteo eggs" (1 page).

Additional material (30 pages) handed out at the meeting included:

1-6. Additional questionnaire reports (published in *Raptor Research* 6(1): 31-41, 1972, as B.P.I.E. Nos. 35-40).
1. Shultz, Philip L. Report on Prairie Falcon (6 pages).
2. Canadian Wildlife Service. Report on Prairie Falcon (3 pages).
3. Canadian Wildlife Service. Report on Prairie Falcon (2 pages).
4. Canadian Wildlife Service. Report on Peregrine Falcon (3 pages).
5. Canadian Wildlife Service. Report on Peregrine Falcon (3 pages).
6. Canadian Wildlife Service. Report on Peregrine Falcon (3 pages).
7. RRF Pathology Committee, names and addresses of members (1 page, part of annual report).
8. Zu/Preem flier (1 page).
9. "The Nutrient Requirements of Chicks" (2 pages).
10. Morgan, Walter. "Artificial Insemination" (outline of procedure; 1 page).
11. Artificial Insemination Panel; Practical considerations in artificial insemination; Berry, Robert B. Abstract—"Artificial insemination of captive goshawks" (4 pages).
12. Berry, Robert B. Abstract—"Foster Rearing of Raptors in Captivity" (1 page).

Those recorded in attendance are listed below.

Allen, David E., 11332 Sunnyslope, Kansas City, MO 64134 (Panel 3).
Andersen, William C., Otero Jr. College, La Junta, CO 81050.
Awender, Erich, 1317 La Cresta Dr., Freeport, IL 61032 (Panel 4 Chairman).

Berry, Robert B., RD 1, Chester Springs, PA 19425 (Panel 7 Chairman, Panel 8, Panel 9).
Beske, Alan E., 83 North 300 East, Springville, UT 84663.
Blankespoor, Gilbert W., Dept. of Biology, Augustana College, Sioux Falls, SD 57102.
Bond, Frank M., 540 Camino Rancheros, Santa Fe, NM 87501.

Cade, Tom J., Sec. of Ecol. and Syst., Bldg. 6, Langmuir Lab., Cornell University, Ithaca, NY 14850 (not present; originally Chairman of Panel 4).

Campbell, John, Box 130, Black Diamond, Alberta, Canada.
Carlson, C. Wendell, Poultry Science Dept., South Dakota State University, Brookings, SD 57006 (Panel 3).
Carnie, S. Kent, 206 Sheridan Rd., El Paso, TX 79906.
Cranson, Babette, RR 2, La Junta, CO 81050.
Crawford, J. Jeff, RR 2, Box 53, Durand, IL 61024.
Crouse, Rodney N., 4311 S. 71st St., Apt. 3, Milwaukee, WI 53220.
Crowe, Sam, 152 Monte Key, Los Alamos, NM 87544.

Dague, Phyllis R., Lab. of Ornithology, 159 Sapsucker Woods Rd., Ithaca, NY 14850.
Donald, Tom, c/o 1930 Cowan Cres., Regina, Saskatchewan, Canada.

Eberly, Lee, Rt. 2, Box 94, Vermillion, SD 57069.
Enderson, Jim, 10070 Otero Ave., Colorado Springs, CO 80908 (Panel 2, Panel 8, Panel 9 Chairman).

Freitag, Gary, 230 Daphne Way, Broomfield, CO 80020.
Fuller, Mark, 1231 Raymond Ave., St. Paul, MN 55108.
Fyfe, Richard, RR 1, Fort Saskatchewan, Alberta, Canada (Panel 2 Chairman, Panel 6).

Galicz, George, 13281 60 Ave., Surrey, BC Canada.
Goben, Bill, 3016 Benson Rd. S., Renton, WA 98055.
Gorrell, Wallace, 1709 S. Duluth Ave., Sioux Falls, SD 57105.
Graham, Dick, Rocking R Rd., Colorado Springs, CO 80915.
Greichus, Yvonne, Station Biochemistry, South Dakota State University, Brookings, SD 57006.
Grier, Jim. Lab. of Ornithology, Cornell University, Ithaca, NY 14850.

Halliwell, William H., Dept. of Pathology, School of Vet. Med., Columbia, MO 65201 (Panel 3 Chairman, Panel 10).
Halverson, Keith J., Great Plains Zoo, Sioux Falls, SD 57104.
Hamerstrom, Fran, Plainfield, WI 54966 (Panel 6, Panel 7).
Harrell, Byron, Biology Dept., University of South Dakota, Vermillion, SD 57069 (Coordinator).
Hinckley, Bob, RR 2, Monee, IL 60449 (Panel 1).
Hoback, Frank, 942 Canyon Rd., Santa Fe, NM 87501.
Hughes, David, Batworthy, Chagford, Devon, UK
Hughes, Francis, Apt. 1417, 100 De Gaspe, Nun's Island, Montreal, Quebec, Canada.
Hunt, Grainger, Dept. of Zoology, University of Texas, Austin, TX 78712.
Hunt, Deidre, Dept. of Zoology, University of Texas, Austin, TX 78712.
Hunter, Donald V., RR 3, Centerville, SD 57014 (Panel 1 Chairman, Panel 11 Chairman).

Ketchum, Sherm, 11610 W. Lincoln, West Allis, WI 53227.

Lawson, Tim, 7013 Hawks Dr., Olympia, WA 98501 (Panel 5).
Layman, Steve, 813 East 4th, Ellenburg, WA 98926.

MacLeod, Mark, 52 Lake Park, Champaign, IL 61820.
McIntyre, James C., 2937 Country Club Drive, Colorado Springs, CO 80909 (Panel 3, Panel 5).
Marcus, Stanley A., Rt. 2, Coleman, MI 48618.
Mattingly, Edwin, University of New Mexico, 508½ B. Prosperity Ave. SE, Albuquerque, NM 87102.
Meng, Heinz, State University, New Paltz, NY 12361 (Panel 2).
Mesch, Ken, Dept. of Biology, University of Colorado, Boulder, CO 80302.
Morgan, Walter, Poultry Science Dept., South Dakota State University, Brookings, SD 57006 (Panel 7).

Nelson, Alora L., Dept. of Biology, University of Calgary, Calgary, Alberta, Canada.
Nelson, R. Wayne, Dept. of Biology, University of Calgary, Calgary, Alberta, Canada (Panel 6 Chairman).

Oar, Jack, RR 5, Box 226, Rockford, IL 61108.
Oberg, John, Route 1, Owen Center Rd., Rockton, IL 61072.
O'Brien, Dan, Rt. 3, Meckling, SD 57044.
Olendorff, Richard R., 3317 Olympus Dr., Bremerton, WA 98310 (Panel 6, Panel 8 Chairman, Panel 9).

Platt, Joseph B., Dept. of Zoology, Brigham Young Univ., Provo, UT 84601.
Porter, Richard D., Patuxent Wildlife Research Center, Laurel, MD 20810 (Panel 3, Panel 10 Chairman).

Rafuse, Bob, 135 Mayfair Cres., Regina, Saskatchewan, Canada.
Richards, Gerald L., 510 Idaho Ave., Provo, UT 84601.
Ricken, Christine, 1200 College Ave. No. 107, Boulder, CO 80302.
Russell, W. C., Omaha Zoological Society, 10th & Deerpark Blvd., Omaha, NE 68107.

Schubert, Teddy, 20 Spring Lane, West Caldwell, NJ 07006.
Schwartz, Charles H., Box 385, Rawson, OH 45881.
Sherrod, Steve, Box 282, Springville, UT 84663.
Shultz, Philip L., 107 Cienega St., Santa Fe, NM 87501.
Simons, Bob, Dept. of Zoology, University of Illinois, Urbana, IL 61801.
Simonyi, Joseph S., 456 Sparton Rd., Victoria, B.C., Canada.
Smylie, Tom, Box 174, Timeras, NM 87059.
Snelling, John C., Cornell Lab. of Ornithology, 159 Sapsucker Woods Rd., Ithaca, NY 14850 (Panel 8, Panel 9).
Snyder, Mrs. Noel, 5113 127th Ave., Tampa, FL 33617 (not present, contributed material to Panel 6).

Snyder, Noel, 5113 127th Ave., Tampa, FL 33617 (not present, contributed material to Panel 6).
Stoddart, John, 430 S. Franklin, Denver, CO 80209.
Stoudenmire, T. Malory, 4233 E. 189th, Cleveland, OH 44122.
Swartz, L. G., Dept. of Biology, Bunnel Bldg., University of Alaska, College, AK 99701.

Taggart, Joe, 143 Browning Lane, Rosemont, PA 19010.
Temple, Stanley A., Lab. of Ornithology, Cornell University, Ithaca, NY 14850 (Panel 4 Chairman, Panel 5, Panel 7, Panel 8, Panel 9).
Thacker, Roger, Dept. of Animal Labs., Ohio State University, 400 W. 12 Ave., Columbus, OH 43210 (Panel 1).
Thomas, J. Gregory, 15 Rolling Springs Court, Carmel, IN 46032 (extra presentation following Panel 6).
Torgersen, Tom, 7844 Torgersen Rd., Eureka, CA 95501.
Trefry, Philip A., c/o R. Fyfe, RR 1, Fort Saskatchewan, Alberta, Canada.

Walker, Skip, Dept. of Biology, University of Alaska, College, AK 99701.
Weaver, Jim, 159 Sapsucker Woods Rd., Ithaca, NY 14850 (Panel 2).
White, Clayton M., Dept. of Zoology, Brigham Young Univ., Provo, UT 84601.
Wilbowr, Craig R., Box 878, Chelan, WA 98816.
Wolhuter, Bruce R., 1405 Willshire, Colorado Springs, CO 80906 (Panel 1).

This report will be issued in parts corresponding to the first ten panels. Pertinent material from the last panel will be included in the appropriate part. The editors of the individual parts utilized the tapes and the transcription mentioned above or their own to prepare the material. In some cases the transcript has been modified for clarity, reduction of repetition, and to provide for more logical sequence. In other cases the individual panel members have rewritten their presentations. The individual reports will be published in the sequence in which they are completed. Pagination will be continuous in this supplement to Volume 6 of *Raptor Research* but page numbers will be preceded by the letter designating the part to distinguish the Supplement from the regular issues.

RAPTOR RESEARCH

Volume 6. Supplement Part B. 1972

SPECIAL CONFERENCE ON CAPTIVITY BREEDING OF RAPTORS–A REPORT

Sponsored by Raptor Research Foundation, Inc.
Held at Sioux Falls, South Dakota, USA, November 22-23, 1971

Part B. Incubation, Natural and Artificial (Panel 8)

edited by
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Bremerton, Washington 98310

Panel Members: Richard R. Olendorff, Chairman; Robert Berry; James Enderson; John Snelling; Stanley Temple.

INTRODUCTION

OLENDORFF. One critical aspect of the wholly artificial method of rearing birds of prey is artificial incubation. Really, it should not be a problem at all considering the state of the art in the poultry business. I would venture a guess that if we gave some fertile eggs to an avian scientist specializing in incubation, he would chuckle at our floundering and hatch out a high percentage of the birds. Berry and Temple will talk about using conditions suitable for chickens or hawks. For this discussion I have considered what literature was available on the various aspects of incubation by falconiforms only, and will review this briefly as we go. I will invite discussion by the panel and the audience of each point separately. Some of the things we will be talking about include temperature, humidity, egg-laying, attentiveness to the first egg of the clutch, candling, and turning. Some other considerations we might want to talk about are egg weight loss, length of the incubation period, the roles of the sexes in incubation, the mechanics of hatching, the analysis of failure to hatch and incubation of hawk eggs by chickens.

TEMPERATURE CONSIDERATIONS

OLENDORFF. Beginning with temperature, all we have to go on is what has

been tried and what small successes have resulted. First we should dispense with the notion that there is a single incubation temperature for a species. We should probably speak of ranges of incubation temperatures and optimum incubation temperatures. Huggins (1941) studied incubation temperatures of wild Marsh Hawks and found that *during attentive periods* the eggs were incubated at an average temperature of 90.1 F. The temperatures varied from 82.9 to 95.7 F over an extended period of observation. In the laboratory Stanley and Witschi (1940) used a temperature of 96.0 F to incubate Red-tailed and Cooper's Hawk eggs when older developmental stages were required for their embryological studies. I incubated two Swainson's Hawk eggs full term at 96.0 F while conducting my dissertation research, but the embryos died in the very late stages of incubation several days beyond the expected hatching date. I understand that this is one result of too low an incubation temperature, but it is difficult to attribute failure to any one cause. Moving up the temperature scale, Hunter (1970) attempted to get incubation temperature readings from captive Goshawks. The average of ten readings was 95.4 F, with a maximum of 97.2 F. Hunter thought that this was quite low. Enderson (1971) used a temperature of 97 to 98 F to artificially incubate Prairie Falcon eggs with some success. He also placed a dummy egg with a thermister in it under some Prairie Falcons. At no time did the temperature exceed 95 F in the center of the egg. I will let him expand on this when I finish. Lawson and Kittle (1970) incubated American Kestrel eggs at 99.0 F and got large embryos, but none hatched. Kish and Clark (1971) used 99.5 to 99.8 F to incubate 5 Golden Eagle eggs, but all were apparently infertile. Dr. H. Mendelsohn of Tel Aviv, Israel, hatched a clutch of Long-legged Buzzard eggs at 100.4 F. Enderson (1971), again with Prairie Falcons, used 101 to 102 F in a still air incubator and 99.2 F in a forced air incubator to achieve success. Again, I will leave the details to him. Hancock (1971) used temperatures of 102 to 103 F top of the egg and 99 F bottom of the egg to incubate Peale's Falcon eggs, but the eggs were infertile. Finally, for comparison, the optimum for chicken eggs according to Bellairs (1960) is 101.3 F which corresponds to the body temperature of the hen. Along these lines, I have seen the body temperature of Marsh Hawks, Peregrines, Red-tails and Swainson's Hawks published as roughly 105 F. Kestrels were somewhat higher at 107 F. Some unpublished data I have indicate that body temperatures of Red-tails and Swainson's Hawks are actually lower than that, about 99 to 101 F depending on the time of day. Perhaps someone can recall other representative body temperatures. Those I took were over a twenty-four hour period ½ to ¾ inch deep in the cloaca. The figures of 105 F may have been deep core temperatures, but the point should be made that incubation temperatures probably do not exceed peripheral body temperature. Another temperature consideration is the matter of allowing eggs to cool once or twice a day. Certainly the eggs of wild birds are cooled periodically during inattentive periods. Eric Stauber reported that Fesner (see Stauber (1971)) cooled eggs to room temperature twice a day and I have seen other references to it. It is difficult for me to see any advantage in doing so. Perhaps there is a greater exchange of oxygen and CO_2 during the cooling and reheating period. If anyone can shed any light on this, please do so.

So much for my discourse on temperature. I'd like to turn it over to Jim Enderson now.

ENDERSON. In the packet that you have received I have spelled out some of the temperatures I have used. These are as follows: In 1970 four Prairie Falcon eggs incubated at 99.7 F, forced air temperature, 75 percent humidity and tilted through 150 degrees at three-hour intervals, while resting on the small end of the egg, died at ages varying from one to three weeks. In 1971 another captive-produced egg hatched after full-term incubation at 99.3 F still air temperature at the upper surface of the shell, 70 percent humidity and about five turnings per day using freshly washed hands. About 80 percent humidity was reached in the last three days of incubation with an air-pump driven power atomizer. Two other embryos died at about 7 days of incubation when the incubator rose to about 101 F because of a faulty thermometer. Hatching in Prairie Falcons requires 50-60 hours; eggs were not rotated at this time. Hatching was aided successfully in one case when it was clear that the chorionic vessels were dry. The eggs were candled daily; embryos appear most active around 21 days, the air space enlarges rapidly after 30 days and hatching of four captive Prairie Falcon eggs required about 35 days. Chicks hatched from the pipped condition in less than 30 minutes. There are a couple of other things I would like to mention. Thermisterized whole eggs appear to give readings 1 to 2 F below the air temperature immediately surrounding the egg. I believe that John Snelling experienced that as well with thermisterized American Sparrow Hawk eggs. Another thing you have to watch is the distinction between still air and forced air temperatures. Forced air temperatures are usually below those used in still air incubators. Another problem is where do you measure the temperature surrounding the egg? In a still air incubator my technique has been to measure the temperature at the upper surface of the egg. In a still air incubator the temperature there is much different than at the lower surface of the egg, the egg being progressively cooler as one goes down through the thermal stratification in a still air incubator. You get into all sorts of complexities because the embryo, at least in early stages, is within a quarter inch, perhaps, in an egg the size of a Peregrine (maybe a little more), of the upper surface of the egg. The forced air incubator is quite a different matter. I strongly suspect that temperatures exceeding 99.5 F are too high for incubation of the eggs of most large raptorial birds.

HINCKLEY. Is that temperature a still air or a forced air temperature?

ENDERSON. I would not raise the temperature over 99.5 F in any case, even at the upper surface of the egg in a still air incubator. The standard temperature used by Cornell in a forced air incubator for chicken eggs is 99.7 F.

HUNTER. That is equivalent to 101.6 still air, right?

ENDERSON. I don't know. Where do you measure the still air temperature?

Actually, I think if the temperatures are of the order of 99.2 to 99.4 in a forced air incubator, the eggs can stand some latitude temperature wise. Probably even temperatures like 98.8 will work. The only difference there would be the time for development.

HUNTER. I think it is important to define exactly where we are measuring the still air temperature. We don't need to worry about forced air. Don't you think some kind of a standardization is necessary? Where do you measure still air temperatures? I measure it 3/8 of an inch below the top of the egg. And then it depends on whether your heating element is above or below, because in a still air incubator the hottest air rises because of the thermal qualities. There are a lot of variables here which I really think need to be defined.

OLENDORFF. The incubator I used had two vents in the top which I left open assuming that that was for circulation of air so that there should be a certain amount of circulation even in a still air incubator.

LAWSON. I think the poultry people measure their temperature one third of the way from the top of the egg.

SWARTZ. Jim, do you find the disparity between air temperature and thermister temperature to be the same in forced air and still air?

ENDERSON. I don't have experience with still air thermisterized eggs.

WALKER. How does this disparity come to be? Do you calibrate these to air temperature? If you did so, you would get a direct read out of air temperature.

ENDERSON. A possibility is that the lower temperature of the thermisterized egg is due to evaporative cooling, although this is a little hard to explain. It would seem to me to take considerable loss of moisture to cool an egg 1-2 degrees at that temperature.

OLENDORFF. Let's get a little more input on temperature.

BERRY. The incubator I used to incubate Northern Goshawk eggs was a forced air, Sears and Roebuck type incubator. The temperature ranged from 99.0 to 99.5 F throughout the hatching period. Relative humidity was kept between 86 and 90 percent. I would say the average was between 86 and 88 percent. Since the relative humidity outside was so high, it was difficult to get the relative humidity down below 90 percent in the incubator. I also hatched some Peregrine Falcon eggs which were taken from the Canadian arctic. I hatched them at the same temperature, 99.0 to 99.5 F. I took some temperature readings of both the Northern Goshawk and the Bantam hen. This involved taking the temperature about 2 dozen times throughout the nest to get a median tem-

perature within the nest area. The Goshawk temperature ranged from 96 to 99 F with a median of 98.5 F. The chicken ranged from 97 to 101 F with a median of 99.5. The chicken was a full degree warmer than the Goshawk which, according to A. van Tienhoven from Cornell and John Skinner from the University of Wisconsin, may have contributed to the death of several Goshawk embryos during the 1970 year—that one degree temperature difference. The maximum skin temperatures of the brood spots were also measured for the Goshawk and the chicken. The Goshawk had a temperature of 101 F and the chicken 103 F. These are not necessarily very accurate temperatures, but it does indicate that the chicken is somewhat higher in incubation temperature than the Goshawk, and apparently some of these other hawks do have a lower incubation temperature than we might expect in domestic fowl.

UNKNOWN. Did you cool the eggs which were successful?

BERRY. Yes. All eggs were cooled twice per day every day including the days immediately preceding hatching for 15 to 20 minutes in a room temperature of approximately 70 F. Werner Fesner suggests that this cooling is very important to allow the reabsorption of oxygen.

HUNTER. The Goshawk under which I took the temperatures would not tolerate a remote sensing device in the nest (Hunter, 1970). I put a temperature thermometer in the nest and she would throw that out except when I went in at night and worked it up through the nest to the desired height. In this way I got the unexpectedly low temperatures. I put a chicken egg under her and it took her 28 days to hatch it. This indicates that the Goshawk is probably incubating at a lower temperature than the chicken.

SWARTZ. The poultry people abandoned this cooling business some years ago, finding that it is not only dispensible, but that the implications are that it may very slightly lower hatchability. The last is in doubt.

BERRY. I think just the reverse of that. John Skinner at the University of Wisconsin also corroborated Werner Fesner and said he thought that cooling would definitely increase hatchability of the eggs.

FYFE. Relative to some of our observations on the prairies, the impression we have is that the birds very seldom remained off of the eggs for any more than a short time. There was a definite attempt for the male to get immediately back to the nest as soon as the female came for food.

TURNING

OLENDORFF. It is generally agreed that eggs should be turned several times daily to prevent adhesion of membranes and, according to the Lanyons, to pro-

vide exercise for the developing embryo.

NELSON. Bob Berry, were you turning the Goshawk and Peregrine eggs a certain number of times per day?

BERRY. All eggs were turned every three to four hours every day, with a reduction in frequency 3 to 4 days prior to hatching. They were turned throughout the day and night, 180 degrees at a turn.

FYFE. We didn't actually observe any turning as such with our Prairie Falcons, but the birds did shuffle on the nest to readjust their position. This would probably roll the eggs. This often happened several times in an hour. Other times the bird would sleep for an hour or so at a time.

NELSON. I have written to a few people here about the studies of gulls which were done I believe in Europe by Dr. Rudy Drent of the University of British Columbia at Vancouver, and there have been a couple of other studies as well of wild birds. They marked the eggs with lines at varying degrees around the egg so that they could determine what part of the egg is uppermost. All of the shuffling we are seeing in the nest, the various shifting of the feet which appears to be threatening the egg, seem to be to keep the egg in exactly the same position so that the embryo is uppermost. If you take a reasonably well-incubated egg and mark a line on it and you put it in a bowl of water, the egg will take up a particular position because a certain part of the egg is heavier. It happens that the embryo part of the egg is lighter and it always floats uppermost. This is the whole purpose apparently of why birds of a variety of species shuffle the eggs. It is shuffling to keep the embryo uppermost and closest to the brood patch of the adult. Artificial incubation in incubators has been done with uncountable numbers of chicken eggs. It is very likely that in chickens we have selected for those birds that lay eggs for which it doesn't matter whether they are upside down or not. Jim Enderson said awhile ago that there is a very great difference between the temperature at the top of the egg and the temperature at the bottom. With the gulls and with the godwits in Europe it has been proven quite conclusively that all of the movement of the eggs in the nest are to keep the embryo uppermost against the brood patch.

TEMPLE. Did that fellow ever candle an egg? You can follow an embryo all the way around an egg as you turn it. The embryo floats in the egg.

NELSON. They have opened a variety of eggs at various stages and it is quite so. It is in the latest issue of the supplement for *Behaviour*.

HAMERSTROM. This all begins to make some sense to me. I marked my Golden Eagle eggs on the bottom as they were laying so I could tell which egg was which. As I went to the nest day after day I never could find those markings. I thought that they had worn off. When I took the eggs away, the marks

were still there. This suggests, although my eyes are not very good without glasses, that those markings were usually at the bottom.

WOLHUTER. Do you have any theories as to why the markings were down? Could it have been the bird's reaction in wanting to put the markings down, or do you think that this was just the position the eggs happened to be in.

HAMERSTROM. I don't think it was the bird's reaction.

HUNTER. This brings up a good point that somebody really ought to check out. Does the position of the shell have anything to do with where the embryo is? I think that no matter where you turn the shell the embryo will stay on top, because it is floating in fluid inside. It is not attached to the eggshell in any way. I have often questioned in my own mind why an egg needs to be turned, but everybody does.

TEMPLE. That is exactly why you turn it. That embryo remains free. If you don't turn it, the membranes will adhere to the shell. Then, later on, if the membranes adhere to the shell and you turn it, you get rupturing of blood vessels.

ENDERSON. The embryo won't float if you don't turn it. I think in this case one picture or 3600 pictures is worth a thousand words. In the summer of 1970 Gerald Swartz, Stan Temple and I took some time-lapse motion pictures of Peregrine Falcons incubating eggs along the Yukon River. I want to run a section of that film for you now. This is just the part where the bird is incubating eggs. This is, of course, greatly speeded up. The frames were taken about 2½ minutes apart. You get a feel for the activity over the eggs. The change in position of the bird on the nest averages out to about once every 30 minutes. I presume that changes such as these involve some movement of the eggs. We did see active turning as well. The manuscript dealing with these films is being submitted to the *Living Bird.* Only less than one percent of the time are the eggs exposed.

TEMPERATURE AND TURNING

TEMPLE. This is a summary of our data from seven Peregrine eyries at which we had time-lapse cameras. A couple of interesting things showed up including the one that Jim Enderson just mentioned. If we assume that Peregrine Falcons in the wild do it the right way, we can probably get some pretty good insight into some of these questions. One very important point is this thing on periodic cooling of the eggs. I think the thing that was surprising to us is that inattentive periods—times when the eggs were uncovered and not actively incubated—were less than one percent of the time. The average time that these eggs were exposed was less than three minutes. In other words, Peregrine Falcons do not

periodically cool their eggs. Less than three minutes of exposure does not allow the eggs to cool down hardly at all. The other thing you will notice here is that the inattentive periods drop off in the last five days before hatch, during which the embryo breaks into the air sac. You will then hear the embryo peeping and scratching around in the egg. With regard to the role of the sexes in incubation for those of you who are going to allow your birds to incubate, quite surprising again to us, the male incubated approximately one-third of the time. The times they were on the eggs per shift were about two hours for the male and 3½ hours for the female. The male definitely (in wild pairs) contributes substantially to the incubation of the eggs. This is quite contrary to impressions of quite a few people who have published on this for Peregrine Falcons. The important thing to note is that the inattentive periods are very insignificant.

HAMERSTROM. How many eyries were involved in your study?

TEMPLE. Seven. Not all of them were involved in each of the periods into which we broke the incubation period.

SMYLIE. Did the inattentive periods correspond to the times when they were changing?

TEMPLE. The information would suggest that it is usually when the male brings food in and the falcon leaves the eggs to go meet him. The eggs are left alone while the food exchange takes place away from the eyrie.

SMYLIE. When he comes in to incubate, how long does it take to make the change from male to female? Even if it is 30 seconds, if it happens enough times during the day, you are going to get up to a 20 to 30 minute total that the eggs might be exposed.

TEMPLE. Here we have the percentage of the total time those eggs were exposed and it is less than one percent.

FYFE. The exchange is a short thing.

TEMPLE. It is very short. The eggs are not allowed to cool. Anyone who has worked with eggs knows that in three minutes that egg is not going to cool very much.

UNKNOWN. Have you every seen the male incubate through the night?

TEMPLE. Yes. The male incubated during the night in approximately the same proportion as he incubated—about a third of the nights.

WOLHUTER. Perhaps Dr. Porter can agree or disagree with me, but it seems that male kestrels do more of their incubating at night.

PORTER. We didn't record data on what happened at night, although the literature has one or two references to it. I believe that Tom Cade published on this.

TEMPLE. Ours seemed to be completely random. In other words, about one-third of the nights—about what you would expect—the male incubated.

UNKNOWN. What was air temperature at these nests?

TEMPLE. This was on the Yukon River so the air temperature was down to 60 to 70 F.

PORTER. Is there any indication of abnormality which might be expected from the pesticide situation?

TEMPLE. We didn't observe anything we could directly relate to pesticides. We did find that at the two eyries out of the seven that failed to produce young, eggs were broken. Thin eggshells did accompany failure. In one nest where eggs were broken and young did not hatch, the tiercel did not fulfill his responsibility during incubation. We only had a camera at this eyrie for a short period because we had a malfunction, but during that time when the female would get off apparently to feed, the male would not incubate his whole attentive period.

ENDERSON. Dr. Porter, that is true. At the two nests that failed, we found the thinnest shelled eggs. Egg breakage occurred at other eyries as well. Small sample size, I'm sorry.

NELSON. When you are talking about one percent or so of the time, this amounts to about 15 minutes per day.

TEMPLE. Right. The inattentive periods averaged about three per day. There were three intervals when the eggs were left uncovered each day. The eggs were left uncovered for an average of less than three minutes each time.

NELSON. How often did you expose a frame?

TEMPLE. About every 2½ minutes. This gives us a less than three minute interval. The bird is incubating in one frame, he is gone the next and he is back the next. This gives you a maximum time of five to six minutes off per exchange, but we are averaging.

GRIER. You have thousands of pictures there and they are using a sampling procedure.

NELSON. In any case, someone made the point that cooling of the eggs was

required for oxygen reabsorption. Fifteen minutes per day may be very important.

TEMPLE. But it is not 15 continuous minutes.

NELSON. But for oxygen reabsorption it doesn't matter.

TEMPLE. Who brought up this oxygen reabsorption business?

BERRY. Werner Fesner is the source of that little bit.

TEMPLE. Fesner is not an expert in avian biology, and I would question that he had done anything to indicate this.

OLENDORFF. From the laws of physics, most of the cooling will occur during the first three to five minutes that the eggs are uncovered. In other words, when the difference between ambient temperature and egg temperature is the greatest, the rate of cooling will be the greatest, and the rate will decrease as cooling continues. I cannot tell you if it is significant or not, but the cooling is faster at first.

TEMPLE. The studies they have done on the cooling of eggs indicate that the albumen is a tremendous insulator. Uncovered eggs retain their temperature for quite a while.

HUNTER. It looks like we are just conjecturing on this. No one really knows. Maybe someone ought to get some data on this.

GOBEN. I watched this fairly closely with my Ferruginous Hawks just to see this cooling period. On the exchange they were very careful not even to let cool air get to the egg. If the female was on, the male would stand right beside her, slip a wing half underneath her and she would lift off. He would then slip a wing over the egg and move over on to the eggs. The opposite exchange would occur the same way. You never get to see the eggs.

FYFE. Our field observations would very closely parallel what you have here for the Peregrines. Most of the movement of eggs was just with the foot movements. The time off the eggs was usually just the time it took for the female to go and get food and the male to come back and go on to the eggs. It would certainly be less than three minutes. We spent a lot of hours observing, but we could have missed periods. I don't think, however, that we would have missed a long inattentive period. With our captive birds we found the same thing. They made very sure that the eggs were incubated virtually all of the time.

SWARTZ. On the general point of cooling, I think we have a relatively foolish situation. The point doesn't deserve too much discussion. As for movement,

I wonder if we are not, in the incubator, substituting with infrequent large movements for very frequent small movements. It is probably not necessary for a bird to roll an egg clear over.

TEMPLE. I might add that most poultry people now have automatic turners in their incubators. This is the way I handled the red-tail egg we got from artificial insemination. It was moved through a 90 degree arc every hour. The egg was never completely rolled over. It was rocked back and forth through a 90 degree arc. It was lying on its side in a normal incubating position.

ENDERSON. Someone might experiment with a clock drive turner using rollers.

TEMPLE. That would save getting up in the middle of the night to turn eggs.

SNELLING. In 1970 I addressed myself to the problem of artificial incubation in the American Kestrel, specifically to all of the questions we are asking today. For logistical reasons I only decided to look at temperature relations and cooling. I had at my disposal a sample of wild laid American Kestrel eggs, 36 fertile ones to be exact. I used a still air incubator, a very simple unit which can be constructed by hand for less than $15.00. I divided my eggs into three temperature treatments. All eggs were in the same incubator. The middle level was at 101 F (38.5 C). The low level was at 97 F (36.0 C). The upper level was at 104 F (40.0 C). These eggs were divided another way. It was a three by two experimental design actually. Half of the eggs were cooled twice a day to about 21 C (morning and evening). The results are shown in Tables 1 and 2. These are the hatching successes for the various temperature treatments. At 38.5 C (101 F), 11 out of 11 eggs hatched normally and they were all raised to fledging. At 36.0 C, five eggs hatched, while eight did not hatch. At 40.0 C, three eggs hatched; nine did not hatch. If you perform a Chi Square test on these data, the conclusion is that 38.5 C (101 F) was the optimum incubation temperature. Bear in mind that there is a distinct difference between still air and forced air temperatures. This was a still air unit in which normally you would have a higher incubation temperature. This would correspond to about 99.7 F which is the proper forced air incubation temperature. Apparently American Kestrel eggs, with respect to temperature, react like chicken eggs. The sensor was simply a dry bulb thermometer at the top of the eggs. The heating element was throughout the entire incubator on the sides.

OLENDORFF. You got better hatching at the lower temperature than you did at the higher. Was that statistically significant?

SNELLING. No. Table 3 shows you what we have with respect to cooling. The eggs were cooled for 30 minutes twice a day down to room temperature around 21 C. Of the eggs which were cooled, 11 hatched and seven didn't hatch. Eggs not cooled, eight hatched; ten did not hatch. The Chi Square test perform-

Table 1. Effects of Incubation Temperature and Periodic Cooling on Artificially Incubated American Kestrel Eggs (Snelling)

Temperature Treatment	Cooling Treatment: 30 Minutes Twice Daily	Not Cooled
36 C		
no. fertile eggs	6	7
no. eggs hatch	3	2
mean age[1] when taken	10.3	11.6
mean hatch time[2]	49.3	78.8
condition unhatched eggs		
no. pipped, fully formed	1	3
no. fully formed, yolk sac external	1	-
no. ¾ developed	-	1
no. ½ developed	1	1
38.5 C		
no. fertile eggs	6	5
no. eggs hatch	6	5
mean age when taken	13.3	12.2
mean hatch time	50.7	44.2
40 C		
no. fertile eggs	6	6
no. eggs hatch	2	1
mean age when taken	9.8	13.0
mean hatch time	47.0	62.2
condition unhatched eggs		
no. pipped, yolk sac external	4	-
no. pipped, fully formed	-	1
no. fully formed	-	1
no. ¾ developed	-	2
no. ½ developed	-	1

[1]days
[2]hours from pip to hatch

Table 2. Hatching Success of Artificially Incubated American Kestrel Eggs as a Function of Incubation Temperature.

	Incubation Temperature		
	36 C	38.5 C	40 C
no. hatch	5	11	3
no. unhatched	8	0	9

Chi^2 (2 d.f.) = 14.63, $p < .001$

Table 3. Hatching Success of Artificially Incubated American Kestrel Eggs as a Function of Periodic Cooling.

	Eggs Cooled for 30 Minutes Twice Daily	Eggs Not Cooled
no. hatch	11	8
no. unhatched	7	10

Chi^2 (1 d.f.) = 1.02, p⟩⟩ .05 n.s.

ed on these data shows no significant difference. My conclusion is that cooling American Kestrel eggs has no effect on the hatch whatsoever. Cooling is not detrimental or helpful.

HUNTER. Is there a difference in the time of incubation at the different temperatures?

SNELLING. I cannot say for sure, because I was not sure how old the eggs were when I got them. Table 4 summarizes data I got from thermisterized eggs. Once again, the general pattern of a two to three degree (C) drop with thermisterized eggs is seen. First of all, concern yourself only with the right-hand column. An experimental pair of birds which was fed on pesticides incubated at 34 to 36 C. The control pair which was not fed pesticides incubated their eggs at 34 C. This is a two to three C drop from what we would expect from incubator temperature. In the next three figures down–temperatures with respect to still air incubator–eggs thermisterized in the incubator at the 36 C, 33 C was

Table 4. Temperatures of Eggs Incubated by Captive American Kestrels and in a Still-air Incubator.

	Thermister Coil under Eggs	Thermisterized Egg
Captive Kestrels		
experimental[1]	31 C	34-36 C
control	–	34 C
Still-air Incubator		
36 C level	–	33 C
38.5 C level	–	36 C
40 C level	–	38.5 C

[1]Fed on day-old cockerels injected with 5 ppm Arochlor 1254 and 15 ppm DDE.

obtained from the middle of the egg by thermister. At the 38.5 C level, 36 C was obtained by thermister. At the 40 C level, 38.5 C was obtained. Consistently lower temperatures at the center of the egg than in the air surrounding the egg were obtained. I would like to reiterate the point that people should be very cautious attempting to "naturally" incubate eggs from what they read from the center of the egg by thermister. If you will recall, the temperature data showed that a low incubation temperature can be just as bad as a high incubation temperature. There are some data from poultry studies that this is not the case with fowl, but I think that at this point in time we had better conclude that a low incubation temperature could be detrimental.

ENDERSON. In 1970 I placed a thermisterized egg under a captive Prairie Falcon which was incubating eggs. The highest temperature I could read was 35 C, which agrees fairly well with Snelling's data. That would mean that the other eggs in the clutch may have been reaching on the order of 36.5 to 37.0 C.

OLENDORFF. Has anyone ever placed thermisters on the surface of the egg?

ENDERSON. No. This is the kind of detail we are going to have to do on it.

SNELLING. Figure 1 just shows the incubator I used. This unit was designed by a poultry scientist at Cornell University. It can be built for under $15.00 and has many uses. It could also be used as a brooder for young raptors. You can see that the resistor wires are strung out along the entire length of the sides. It is made out of a styrofoam ice chest. It is a simple unit to use. It can also be adapted for battery powered use. While I still have the floor, let me complete the results of this particular study. The mean time of hatching from the time which the eggs pipped until they actually emerged was 55.4 hours. This agrees well with what the Snyders found with their Cooper's Hawk eggs. Everybody here who has watched an egg hatch will bear me out in this—one is strongly tempted to hatch them artificially, to start picking away at eggshells. This is the worst thing you possibly could do. The natural situation is perhaps two days. I think you should just be patient and wait. As Jim Enderson has aptly pointed out, assistance to the young birds at hatching can be disastrous. The embryonic circulatory system may not be reabsorbed, resulting in massive bleeding, and unbilical infections.

LAWSON. What is an estimate of the age of the youngest egg you started with?

SNELLING. The eggs ranged from about two to about 22 days of age when they were taken from the wild. The grand mean would run around 12 days, so they were about one third incubated when I got them. Statistical tests on the age of the egg with respect to the temperature treatments showed no significance. They were randomly placed in the different treatments.

GRIER. You might point out that Jeff Lincer has incubated a lot of eggs in captivity using the same technique.

SNELLING. Jeff Lincer is a graduate student at Cornell who has done his research on Kestrel-pesticide relationships. He had a very bad hatch this year. Less than 50 percent of his eggs hatched. He was using 97 F for his incubation temperature.

ENDERSON. Eggs can be easily turned without actually handling them by placing them on a sheet of paper toweling and sliding the paper toweling, the eggs being held in the rack by wires on either side.

GRAHAM. Talking with poultry people, they indicate to me that the largest mortality is at about nine to 11 days. Eggs obtained later on might be expected to have a higher hatch rate than natural.

SNELLING. That is very true. However, 11 of 17 eggs which did not hatch reached either completely developed embryos in the egg or pipping. I think that the most critical time was at hatching.

GRAHAM. The poultry people indicate two times of high mortality at nine to 11 and then at 18 days in a chicken egg.

HUNTER. With Prairie Falcons, two clutches with which I cooperated were hatched at 101 F. One hatched within two days after they were removed from the nest in the wild. The other hatched seven days after removal from the nest. This was still air incubation.

OLENDORFF. From my own experience, I found in two cases, young which had difficulty hatching were also difficult to raise during the first five days. They simply died.

SMYLIE. Snelling, did you have a fan in your unit?

SNELLING. No, it was completely a still air unit.

SMYLIE. Could you put one in? Have you had any plans for that?

SNELLING. No, it could be done I suppose.

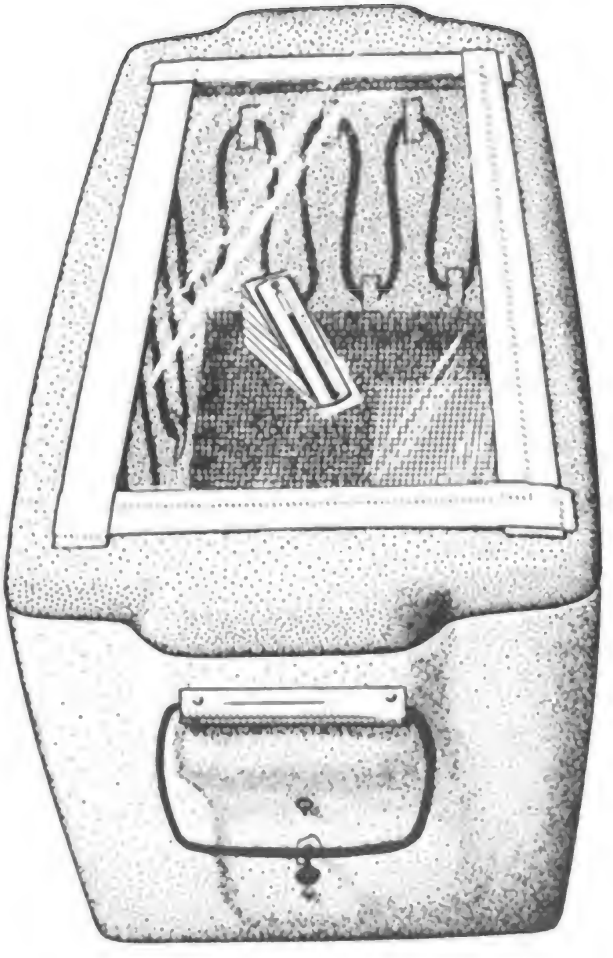
NELSON. How humid was the environment in your incubator?

SNELLING. I didn't mention humidity or turning. I did turn the eggs four times per day at least 180 degrees. The humidity I figured I couldn't control very well. In a situation where I had cloth wicks projecting out of the pans of water in the bottom of the incubator I have a rough humidity measurement of

Figure 1. The still-air incubator employed to incubate American Kestrel eggs. The size of the unit depends on the type of styrofoam ice chest from which the body is constructed (Snelling, from Schano, 1969).

Abstract of "How to make a still-air incubator" by E. A. Schano.
(4-H Poultry Science Incubator Project, pamphlet 1-8-1a, 6 pp., rev. 1969. N.Y. State Coll. of Agric., Cornell Univ., Ithaca, N.Y.)

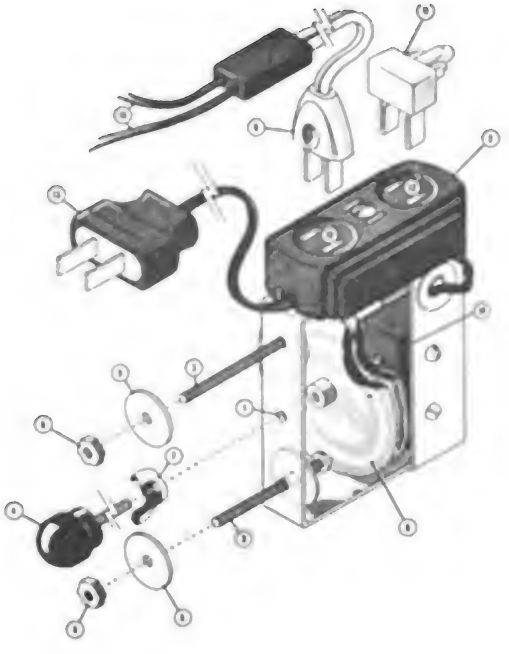
1. Use styrofoam plastic ice chest (12-16"x20-24"x12-15").
2. Cut ¼" welded wire 6" wider and 6" longer than inside bottom; cut 3" squares from corners, fold the sides down, test for loose fit, tape edges to prevent punctures.
3. Place three rings of masking tape inside—2½" from top, 1" above screen, and half way in between.



4. Install microswitch assembly (see illustration): *a.* place assembly so center hole (1) is ca. 5½" down from the top on one end with outlet box (2) on top; *b.* with pencil make three holes for two bolts (3) and control bolt (4), insert bolts from inside, add washers (5), tighten nuts (6) until firm; *c.* insert control bolt (4) with locking wing nut (7), screw into either wafer (8); *d.* insert heating cable plug (9) into outlet (10) and pilot light (11) into other outlet; *e.* to check, plug cord (13) to 110V source, pilot light glows when wafer (8) in contact with micro-switch (14), cable warms, turn control bolt clockwise until click heard and pilot out, turn control bolt counterclockwise until click heard and pilot goes on and cable warms; *f.* disconnect. (Heating cable, thermostat, and thermometer available from Lyon Rural Electric Company Box 30, San Diego, CA 92012; ask for New York Kit and No. 66 Incubator Thermometer; as of July 1971 price including postage and handling was $11.55.)

MICRO-SWITCH ASSEMBLY

1. Centerhole
2. Convenience Outlet Box
3. Bolts
4. Temperature Control Bolt
5. Washers
6. Nuts
7. Self-locking Nut
8. Ether Wafer
9. Plug
10. Convenience Outlet
11. Pilot Light
12. Convenience Outlet
13. Lead Cord Plug
14. Micro-Switch
15. Heating Cable



6. Make observation window on top of chest: cut around glass on cover ¼" into styrofoam, cut hole in cover ¾" inside this cut, and cut out strip ¼" thick and ¾" wide, insert glass, fasten with tape.

7. Make ventilation holes: on long sides make four holes with a pencil 2" from top and 4" apart and four holes 3" from bottom and 4" apart.

8. Test: put cake tin (9x14x1½") under screen with ½" of warm water, put thermometer 1" above screen, plug in, turn control bolt until pilot on, adjust to desired temperature. (Abstract–B.E.H.)

70 percent.

WOLHUTER. You mentioned that the birds which had the most difficulty hatching were the hardest to raise after hatching. Could this be a natural selection against weak birds?

OLENDORFF. I think that those which had a difficult time hatching were simply too exhausted to even accept food and swallow it.

MENG. I noticed with my Peregrine when she laid, in fact she had three eggs at the time, that the eggs were not in the center. They were around her body. She was sitting on the sand and her wings were just covering the eggs to keep the eggs from freezing. It was cold outside. After she had a full clutch, I found the eggs under her. I was wondering if in the wild the bird could be setting on the eggs and the eggs could be at the bird's side under her wings and they could be cooled that way.

ENDERSON. We have time-lapse photos of Prairie Falcons at the time of egg-laying in Colorado in 1971 and it is clear that at this one eyrie the degree of incubation, i.e. the time spent incubating per day, increases from about ten percent or so after the laying of egg 1, until about 90 percent after the laying of egg 5. We saw that at dawn and at dusk the frequency of which the bird was on the nest increased rapidly. Apparently, the birds do sit on the eggs at night even after the laying of the first egg.

MENG. Could the eggs be under the wings so the temperature would not be up?

ENDERSON. I don't know.

PORTER. In our kestrels we found that although the females were sitting on the eggs, they were not warming the eggs until late in egg-laying. They would probably keep them from freezing, however.

WHITE. It is important to remember that the genus *Falco* has brood patches on the sides, rather than in the middle.

MENG. The eggs were quite far apart, and later when she was really actively incubating they were together.

HALLIWELL. It would seem to me, just thinking of it from the practical standpoint that the eggs would be less vulnerable to gross temperature changes immediately after the laying of the egg, at the moment you have a blastoderm with one or two cell layers. Just a chilling of an embryo in the early stages will not cause death. Later on you probably will.

TEMPLE. This is well known to poultry people. In fact, right after laying, they put them in a refrigerator and hold them until they have a large batch that they can start incubating at the same time. They store these eggs for up to six days without a decrease in hatchability.

ENDERSON. I think 40 F is the preferred temperature.

HALLIWELL. The other thing probably is that the falcon gets more maternal the more eggs she has.

RICHARDS. At the end of March, one of my kestrels laid two eggs. About this time the temperature went down to -12 C. I was worried about the eggs freezing so I stayed up a whole night and a day to watch to see what happened. The female would go into the nest box and stay there for a while and then leave. Every time she left I put a thermometer underneath the eggs. She would take the egg up to about 16 C, but it wouldn't get higher than that. I never recorded a temperature lower than about 0 C. As soon as several more eggs were laid the temperature went up to 25 C and higher.

HUMIDITY

OLENDORFF. Humidity is another problem. Most people who have tried artificial incubation thus far have not bothered measuring it. I simply kept a shallow pan the size of the bottom of my incubator filled with water at all times. Enderson and Mendelsohn in separate experiments used humidity as high as possible. Kish and Clark (1970) measured it at 86 percent. Stauber (1971) stated that Fesner actually sprayed a fine mist of water on the eggs he incubated and had nearly total success when he did so. Although there are some data that submerging eggs quickly in water decreases hatchability, a fine spray may indeed increase hatchability. If we talk about the microclimate of the egg during incubation, it is certain, according to Wesley Lanyon who knows a great deal about hand-rearing passerines, that considerable moisture is supplied to the eggs from the skin of the brood patch. Furthermore, incubating birds have been observed to bathe and almost immediately return to the eggs. During my recent stay at the American Museum of Natural History I spoke with Jean Delacour who has artificially raised countless birds of scores of species in France, and to Wesley Lanyon. Both Delacour and Lanyon spoke of using the highest humidity possible and spraying or painting the eggs periodically with water. In the Lanyons' article on hand rearing young passerines, they state that "When the eggs begin to pip, the moisture should be increased. The glass on the chamber door should show some moisture condensation during the hatch. If necessary, one can place sponges in the water pans at this time to increase evaporation. . . . Too little moisture restricts movement within the shell and may make the membranes too dry and tough for the chicks to penetrate." I note along this line that incubation attentiveness in Enderson, Temple and Swartz's study increased

in the five days preceding hatching. In the still air incubator I used for the Swainson's Hawk eggs there were vents for circulation of air and the eggs were simply laid on ¼ inch mesh hardware cloth. The eggs were, for all practical purposes suspended in air. I would suggest that this may have had a considerable drying effect on the eggs in spite of my attempts to keep the humidity high. Never did water vapor condense on the glass portions of the incubator. It is possible that the embryos met with the fate that the Lanyons suggest. This is pure speculation on my part.

TEMPLE. With the red-tail eggs we incubated absolutely as though they were chicken eggs, we, of course, had a very close measure of the humidity in the incubator. During the major portion of the incubation period, from laying up to five days before hatch, the humidity was maintained between 75 and 80 percent. During the five days just prior to hatch, after the young had broken into the air sac, the humidity was raised and held as high as possible, which usually meant slightly over 90 percent relative humidity. This is standard procedure with the poultry industry. They have a separate chamber that they call a hatcher where it is possible by the use of cloths suspended and soaked in water to increase the humidity. As Olendorff said, this is very important to prevent drying of the membranes.

OLENDORFF. We have had a lot of failure of incubation in the very late stages. Remember Frank Beebe and his work with Peale's Falcons. Everyone was questioning humidity at that time several years ago. I feel that that was a fair analysis of the situation.

HUNTER. Is there any danger of too high a humidity at any stage?

TEMPLE. Actually, I think the poultry people would say no. You cannot overdo relative humidity in the air. There have been a number of experiments performed on this dipping of eggs and spraying them.

HUNTER. With goose eggs this is apparently necessary.

TEMPLE. That goose egg experiment was done again, and what they found was that they increased infection of the embryo by moistening the surface of the egg. Getting the surface of the egg moist allowed bacteria to enter the pores of the egg and cause infection in the developing embryo. So, probably it is not a good idea to get the surface of the egg moist. There is a different situation with waterfowl where, as with a goose, every time the bird gets on the egg she brings water.

HUNTER. Ducks hatch so easily that if you keep them moist and put them under the register behind the stove they'll hatch.

NELSON. There is some good information for Ospreys as well. They actually

bring water. Welty cites some literature example concerning this. Has anyone actually seen with raptor incubations that wetting eggs will cause infection?

TEMPLE. This was a general sort of thing with many poultry eggs. I might add that with the Ospreys there was some artificial incubation done this last summer. I think the sample size was somewhere around one dozen eggs. The hatchability was as good as you would expect from the wild. The incubation was done once again precisely as with chickens. I think seven out of the 12 hatched.

RICHARDS. I would like to comment on something that impressed me in reading about Lanner Falcons in the Sahara. It said that for 100,000 square miles or something like that in any direction there was hardly any vegetation let alone a water hole. Still they are nesting out there. It would be impossible for them to get a drink, let alone bring back water on their feathers.

TEMPLE. Just an observation on those nesting Peregrines, there weren't very many times during incubation when the falcon came back to the eggs appearing to be wet like she had been in the water. This was not true during the brooding period. During brooding the falcon would often come in obviously just returning from a bath.

ENDERSON. I wouldn't say it was very often even during brooding.

WHITE. One point that is fairly clear with nearly all types of birds, for anyone who has done anything with passerines, that under the brood patches birds have a very jelly-like area. The brood patch is a highly vascular area with a lot of moisture and lipid there. This does provide moisture through the skin to the egg.

PORTER. I noticed in the American Kestrel just after the eggs were laid, they had a rather rough surface. As incubation started, the eggs developed a glossy, almost waxy-like, texture on the surface. This was probably involved with this brood patch.

WHITE. The brood patches are a very important physiological phenomenon where the blood vessels engorge just below the skin.

OLENDORFF. I wonder if it wouldn't be a good index for high humidity to use the technique of Lanyon of observing water condensing on a piece of glass on the door of the incubator.

TEMPLE. That's of course, just a function of the gradient between the incubation temperature and the outside temperature.

OLENDORFF. Yes, but if the incubators are in rooms near room tempera-

ture and the incubation temperatures are roughly 99 F, condensation would occur at nearly the same relative humidity each time.

GOBEN. In 1965 I raised two prairies. For what it is worth, twice a day for an hour, I would take a wet cloth and wrap the two eggs. I always had a pan of water in the incubator. I also had problems of the chick sticking to the membrane at hatching and I took a dropper with water and moistened them.

GRAHAM. In Germany a very successful hatcher has a heating element in his water. Five days prior to hatching he turns it on. By heating the water you get more evaporation and a higher relative humidity.

ENDERSON. I used a pump driven atomizer to obtain 80 percent relative humidity in an incubator in Colorado Springs. In our climate 70 percent humidity is no small chore, since the humidity of the outside air is about 15 percent. Another possibility which occurred to me was to use an aquarium pump and air stone submerged in the water pan at the bottom. You will have trouble getting too much humidity.

SWARTZ. There are available very convenient electronic hygrometers.

ENDERSON. We had one hooked into the circuit for the atomizer so when the humidity fell below 80 percent, the pump came on.

INDETERMINATE EGG-LAYING

OLENDORFF. Egg-laying has not presented major difficulties except where females have become egg bound. We have spoken to this point earlier. Just to point out a few facts about egg-laying—it is a fairly widespread characteristic that falconiforms lay their eggs every 48 to 60 hours on the average. Variation does exist and it is not uncommon for 72 hours to pass between eggs. In the wild, birds of prey desert most easily at egg-laying, a point to remember when disturbing your birds. One interesting aspect of egg-laying is whether falcons and hawks are determinate or indeterminate layers. Determinate layers produce a fairly constant number of eggs (say four in the case of most shore birds) and then stop laying—period. Indeterminate layers will continue to lay eggs as their clutches are removed one by one at the time of laying. Ratcliffe (1963) states that Peregrines do not usually continue to lay if an incomplete set of eggs is taken. Davenport (1900) was able to collect as many as 16 European Sparrowhawk eggs from a single nest by removing each one soon after it was laid every other day for a month. Dr. Porter has some evidence that this is also the case with American Kestrels and I would like to give him the opportunity to expand the comments he made yesterday about indeterminate laying.

PORTER. I think that Green, who studied the Peregrines in the Aleutians

early in the century removed eggs and got renesting in very short periods of time. I would suspect that the Peregrine follows the same pattern as the kestrel. I ran an experiment using four single female kestrels from which I removed each egg as it was laid. I used four other females, but I left one egg in the nest at all times. Three other females I let incubate normally. The latter females laid the usual five-egg clutch and incubated them consistently even beyond the normal incubation period. Those from which I removed eggs, but left one egg in the nest, one female laid eight eggs at the normal two-day interval and then had a gap of 12 days before laying five more eggs. After a gap of 11 days, five more eggs followed; then, after 14 more days without laying she laid four more eggs. She laid 22 eggs in all. Another female which was always left one egg laid 23 eggs with the greatest interval of only four days between eggs. A third one laid 18 eggs with the greatest interval being six days. A fourth female laid eight eggs with the greatest interval of four days. This suggests that if they are indeterminate, they are just now evolving the capability. There is some variation within the species. Those from which I removed all eggs as they were laid, one female laid only three eggs and laid them very late. Another laid 13 eggs with the largest interval between eggs being five days. Another laid 26 eggs with the largest interval being four days. The fourth female laid 17 eggs with the largest interval being five days. A five- or six-day interval is probably not a recycling interval. The latter ranges from nine to 17 days in the kestrel. The following year I placed four eggs in a kestrel nest after the female had laid her first egg. She continued laying until she had laid a total of four eggs. This was a second nesting for the female for the season. Very frequently, on the second nesting, one fewer (four) eggs are laid. I feel that the four-egg clutch was complete. Thus, she laid a full clutch despite the fact that additional eggs were added to her nest. This supports the hypothesis that the American Kestrel is an indeterminate layer.

OLENDORFF. It makes us wonder if there really is much difference between the concept of indeterminate laying and recycling. In the case of your kestrels there is represented some middle ground between the two concepts.

THOMAS. What happened with regard to fertility in these cases?

OLENDORFF. Davenport (1900) did not mention fertility. The point is that with artificial insemination one could fertilize the excess eggs.

PORTER. All of the birds I used were single females.

GRIER. The ones at Cornell last summer were almost all fertile. This involved 23 and 26 eggs from different pairs of kestrels.

HUNTER. Did you have any problems with calcium, Dr. Porter? Was there any dietary supplementation? Was there any thinning of the eggshells?

PORTER. We didn't get any appreciable differences in texture on eggshells

until we reached about the 19th egg in 1967. The thickness of the shells remained fairly constant, while the texture began showing signs of deterioration. In 1970, even the 26th egg appeared to be in relatively good condition.

OLENDORFF. We don't have to be that greedy. If we just got two or three more Peregrine eggs—.

HUNTER. Did you do anything to the diet?

PORTER. No. We just gave them our normal kestrel diet.

OLENDORFF. It seems that if you did want to get more eggs by these methods, you would supplement the diet with calcium.

HALLIWELL. The calcium which goes into the eggshell indirectly comes from the diet, but the bird must take it in in the correct ratio. It must be absorbed and then stored in the bone. It is withdrawn from the bone back into the serum and then goes to the shell-forming portions of the body. Feeding more calcium during the laying period is not sufficient. You must have a build-up of calcium previous to egg-laying.

ENDERSON. In 1971 my nine year old Peregrine laid a clutch of four eggs. I removed them and she then started on a clutch which eventually yielded 13 eggs. I left a single egg in the nest at all times. This went on until the 11th egg at which time I took the bird out of the room and blocked her down. Two more eggs were laid while she was on the block. Both of these had ultra-thin, soft shells; the last one was unpigmented.

OLENDORFF. The Peregrines, then, seem to be indeterminate layers.

GOBEN. With my Ferruginous Hawks this year, the seventh egg was obviously lacking. The color was completely abnormal. It was odd-shaped and broke the second day.

BERRY. It would appear that at least one female Goshawk is not an indeterminate layer. For five separate years she was allowed to retain only one egg in every clutch which she incubated. In several of these years all eggs were taken and she failed to recycle or lay additional eggs.

OLENDORFF. We are all sorry to hear that.

BERRY. There was also appreciable shell thinning in the three eggs she laid in 1971 from the first to the last shell. The last shell seems to be only about half as thick as the first shell. She was vitamin supplemented for at least two months prior to egg-laying with calcium glutonate about three times a week.

RECYCLING

OLENDORFF. It is well known from egg collecting days that many raptors have the capability of completing a successful nesting even if their first clutch of eggs is taken. Bond (1946) mentions two observers taking 12 fertile Peregrine eggs from the same eyrie in the same year (three clutches of four) and a fourth clutch of undetermined number was laid. The potential for recycling seems to be related to the time invested in any given set of eggs. If young are destroyed, birds will rarely, if ever, renest. An interesting question for study would be to figure out how long you can let the parents incubate before recycling is curtailed. The reasoning here is that we have had trouble with full-termed incubation, but relatively less with short-termed incubation. The Lanyons and aviculturists in general have little or no luck incubating passerine eggs full term. The possibility remains, however, that we could allow captives to incubate for two weeks, then recycle and increase our chance of successful artificial incubation by taking advantage of natural incubation of the parents at first. Perhaps we will be able to leave them under the parents until candling is feasible and then to recycle the parents.

ANDERSEN. We have been working with Swainson's Hawks for about three years now. In any case, if the nest is destroyed during the first week of incubation, there will invariably be a renesting. We have yet to find any case where a successful renest has been made after two weeks of incubation. We see nests relined, but never relaying. If we use this approach, probably no more than one week of incubation by the parents will be possible with the buteos.

NELSON. In the wild Peregrines this year we had two nests which lost young and one of the pairs lost their youngster within the first week after it hatched. They slipped right back into courtship behaviors we would expect prior to egg-laying. They did not lay eggs, however. I mention the point because we may think that if we get the early courtship activities, we will get eggs. If this happens during a recycling procedure after one clutch of eggs hatches, there is not much hope for a second clutch.

HUNTER. I did not take the eggs away from my Peregrine until the 13th day. They went through all of the courtship again, but no eggs were laid.

GOBEN. Lester Boyd had three clutches of Prairie Falcon eggs from a single pair and he removed eggs on the 14th day each time.

PORTER. We have some instances with the kestrels in which the female laid the first egg of her second clutch before the young of the first clutch had fledged or left the nest box. Apparently, the recycling was initiated at some earlier time even when the nestlings were younger, probably 14 days prior to fledging.

WOLHUTER. I question the fact that birds that tend to nest early in the sea-

son or late in the season have smaller clutches. I wonder if the time of year we are trying to get the birds to recycle is important. If it gets to be too late in the summer when you try to recycle, are you missing your whole chance? Should you start the whole process early so you have more time later in the year for a second clutch?

PORTER. Our data on removing eggs suggest that the later the birds start laying, the fewer eggs will be laid in a sequence.

GRIER. Part of this might be tied in to photoperiod considerations. Later on, day length is starting to drop off. It might be possible to keep things going by maintaining a long photoperiod.

GALICZ. I have one pair of Peregrines that laid in late March and incubated for 39 days. Fourteen days later she began laying a clutch of three eggs. Again, after a second full incubation period on August 18 she began a clutch of three eggs. I did not use artificial light.

PORTER. As you found with Peregrines, we also found with kestrels that about 12 to 13 days was the average period for recycling, from the time the first clutch was removed until the first egg of the second clutch was laid. We found also that the period from the time that they were paired and placed into pens with a nest hole to the time it took to stimulate reproduction was about 12 to 13 days. This is in press in *The Condor* at this time.

HUNTER. How many of the kestrels which successfully raised young recycled after they raised young?

PORTER. I don't have those data. The percentage was rather low.

HUNTER. Does anyone know if that is common in the wild?

ANDERSEN. We did some work on clutch size of Swainson's Hawks two years ago and looked at replacement clutches. The replacement clutches were the same size as the original clutch in every case. As far as raising them, we get a much lower success ratio of second clutches.

WOLHUTER. I think it is your southern birds that would have a higher incidence of recycling at least with kestrels. I think it would be interesting to take eyass birds from very far south and put them in a breeding project and see if there is a higher tendency for them to recycle.

WHITE. There is one literature citation in the publication of the London Academy of Sciences where it said that Peregrines in Africa near the equator do lay twice a year. We need to substantiate this statement.

TEMPLE. In arctic Peregrines, this year on the Colville River we discovered for the first time an arctic Peregrine with a replacement clutch. The bird broke her first set of eggs, and laid a second clutch.

PORTER. How far along were those birds in incubation?

TEMPLE. We could not tell because the eggs were broken when we got there.

UNKNOWN. What happened to the second clutch?

TEMPLE. The second clutch hatched and the young were dead when we made our second float.

BERRY. In the Ungava region of northern Quebec I took four Peregrine eggs this year and artificially incubated them. They were taken at the mid-point of incubation. Two of the four eggs hatched. I went back a month later to see if those birds had recycled, and while both adult birds were on the actual eyrie ledge there was no indication of a recycling. At least a recycling attempt did not result in eggs being laid.

CANDLING

OLENDORFF. I realize that candling is a very simple procedure. I've never done it and I'm sure many of you haven't. Perhaps Jim Enderson would tell us a little about it.

ENDERSON. My experience with candling is limited to the eggs of Prairie Falcons and Peregrines. Only the Prairie Falcon eggs contained embryos. The presence of an embryo can be determined using a standard commercial candler, or a two-lb coffee can with a 40-watt bulb inside and with a small hole about the size of a quarter in the lid. By rotating the egg after four days of incubation, that is four days after the completion of the clutch, and waiting for the yolk to come up, you can see behind the pigment layer a distinct shadow cast on the inside surface of the shell. You must be careful not to overheat the egg, because with the coffee can device a great deal of heat is generated. I turn the light off between candlings. Bob Berry has mentioned that the problems of candling Goshawk eggs are not the same as with falcons. As the embryo gets bigger, after about the 24th or 25th day, it is nearly opaque and very difficult to see motion. The easiest thing in that case is to turn the egg so the air sac end is down. As the light comes up along the side of the air sac, you may see motion where the embryo pushes against the air sac and casts a shadow on the side of the egg. By about 32 days the air sac enlarges rapidly and you must avoid the impression that the embryo is dead and that the egg is suddenly drying out. On about the 34th day the embryo will break the air sac and motion is again easy to see. Pipping in Prairie Falcons usually takes place around the 34th or 35th day. At

least two more days are required before hatching occurs.

EBERLY. How large is the embryo at 10 to 15 days?

ENDERSON. By about the 10th day it is still under one cm long.

BERRY. At six to seven days in Goshawk eggs you can see a pea-sized dark spot. You can see the blood vessels around that spot. The circumference of the area of blood vessels might be the size of a quarter.

ENDERSON. Especially with the pale Prairie Falcon eggs, the vessel system is obvious by two weeks.

TEMPLE. People have been worried about the possible deleterious effects of candling. The poultry literature suggests that as long as candling is done quickly and you don't expose the egg to the heat of the candler, candling has no adverse effect. I candled the red-tail egg I hatched sometimes twice a day every day.

PORTER. At times when I would open the nest boxes of the kestrels the bright sunlight would hit the eggs directly. I've had the same thing occur with Prairie Falcons in the wild. Does anyone know if this has deleterious effects on them?

FYFE. One time we set a blind up and the eggs were exposed to direct sun for quite a while. The outside temperature was between 50 and 60 F. The bird was off the nest for an hour and 20 minutes. All eggs hatched.

HUNTER. I use a slide projector for candling. You just use your hand. In seven days you see blood vessels all over the inside of the egg. In my limited experience, if you can see anything inside the egg at seven days, it is probably fertile.

NELSON. In the wild Peregrine on the coast where the air temperature almost never gets over 68 to 70 F, it is very obvious, possibly without exception, that the female incubates during the heat of the day. She just will not let the male come on until the eyrie gets into the shadow. Are there changeovers in the taiga Peregrines that will allow the sun to hit the eggs?

TEMPLE. At one eyrie which had a very sunny exposure, there frequently occurred over-heating of the young and an adult was often present to shade the young. I do not recall about changeovers during incubation, but they changed about every three hours, so there must have been changeovers during the sunny part of the day.

NELSON. One thing that alarmed me one day when I went to an eyrie the day that one of the eggs hatched (the adult female was off the ledge for less

than a minute by the time I got to the scrape) the young bird was on its side thrashing and squirming. As soon as I shaded it, it was perfectly all right. You would think it would lie motionless. I think some of the reaction was to sun light.

TEMPLE. We will show exactly that in some of our films for the next panel.

OLENDORFF. Let's use that as a lead in for the next panel.

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RAPTOR RESEARCH

Volume 6 Supplement Part C 1972

SPECIAL CONFERENCE ON CAPTIVITY BREEDING OF RAPTORS—A REPORT

Sponsored by Raptor Research Foundation, Inc.
Held at Sioux Falls, South Dakota, U.S.A., November 22-23, 1971.

Part C. Behavioral Considerations to Egg-laying (Panel 6)

edited by
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Panel Members: R. Wayne Nelson, Chairman, Richard W. Fyfe; Frances Hamerstrom, and Richard R. Olendorff. A paper submitted by Noel and Helen Snyder was read; unfortunately they were unable to attend the conference.

INTRODUCTION by R. Wayne Nelson

By considering the behavior of captive birds of prey prior to and during the time when eggs might be laid, it should be possible to learn much which could be applied toward the goal of achieving reliable production of captive-bred offspring. One of the major problems confronting captivity breeding is the acquisition of fertile eggs. In the many instances in which no eggs, or only infertile eggs have been laid, it could be presumed that at some point in the courtship behavior or sexual development one or both members of the captive pair had been blocked. Observations of the behavior of the captive birds should indicate where some of the problems lie.

This panel attempted to outline the courtship behavior of some wild and captive raptors, and discussed various methods whereby the captive birds might better be induced to take on the behavior and condition necessary for reproduction. The emphasis on the larger falcons reflects the urgency of the problem with those species; the information from other species provides very useful suggestions for captivity breeding of the larger falcons, due to similarities which appear within many of the species, and due to techniques which have been worked out with the other species.

Unfortunately, we must (literally or figuratively) leave the owls in the dark. There is a general lack of knowledge concerning much of the behavior of the owls prior to egg-laying.

The panel also attempted to indicate what some of the behavioral problems are, and how they might be avoided. The aim of the panel was to stimulate and encourage a better appreciation of what it takes to get birds of prey to behave appropriately in captivity, so that their behavior will bring them to reproduce successfully.

THE NEED FOR A CHANGE IN DIRECTION–TOWARD THE SAME GOAL
by Richard Olendorff

Introduction. Before getting started on the topic of behavior I would like to say that the other people on this panel, and certainly many of you in the audience, have spent more time contemplating the behavioral aspects of the captivity breeding of raptors than I. I suppose I am here because I wrote a lengthy review article on falconiform reproduction with emphasis on behavior, and carried out a very small captivity breeding project with one pair of American Kestrels during which rather detailed behavioral observations were made. Nevertheless, I consider my knowledge of falconiform behavior rather superficial and propose only to speak in generalities for the next several minutes to set the stage for the other panel members. In doing so, I would like to combine some aspects of the review article with some of the results of the kestrel breeding experiment.

Importance of Behavior. First of all let me point out that animal reproduction has often been researched with too little emphasis on ethology or behavior. Falconiform behavior *must* be important to us, but there is danger, too, in holding to stringent paradigms in the name of esthetics or ethology. So we must strike a balance which will result in production, a balance which may involve considerable artificialization (if I may coin a word) of the breeding sequence and conditions in general.

I used to think that habitat simulation and forced fulfillment of complete repertoires of reproductive behavior were the answers to all of our problems. I used habitat simulation with my kestrels with some success. As it turns out, though, this technique works very effectively for kestrels, but it is neither an effective nor an efficient method of rearing *large* falcons. This follows directly from the fact that copulation-producing behavior is an immensely complex sequence of events. Thus, we should glean only what is necessary from wild falcon behavior, and environment for that matter, emphasizing as we go those aspects which will increase the production of captive birds.

Introducing the Birds to Their Mates. Introduction of males and females has been discussed at great length. Although introduction is probably a problem in

itself, it is closely related to pairing in general. We have two types of pairing situations to consider: (1) the male with the female, and (2) the male *and* female with man in the artificial case. In raptors, as with any species of bird, pairing requires a great deal of adjustment, probably more than usual with the pugnacious raptorial species.

The worst failure is the situation in which the female will not tolerate a mate in the same room, the problem being introduction.

Pair-bonding. Assuming that the birds are successfully introduced, the next behavioral requirement is initiation and strengthening of the pair-bond. Of almost equal importance to the hormonal considerations discussed earlier at this conference are all forms of courtship such as mutual roosting, cooperative hunting, courtship flights, courtship feeding, and nest scraping (or building) to mention but a few. I think we can skip the matter of induction of physiological readiness, which has been substantially (albeit inconclusively) discussed already, and move on to eliciting copulation.

Toward Copulation. Pairing and copulation-producing behavior have one very important thing in common; they involve sequentially presented stimuli which result in a sequence of responses. If the sequence is interrupted, reproduction may be inhibited through the neuroendocrine system. If the sequence develops adequately, reproductive processes will continue.

Let's consider the components of the sequence leading to copulation.

Mutual Roosting. Cade observed it in wild arctic Peregrines; Nelson has not observed it in wild Peale's Falcons. My kestrels engaged in it by the hours. In any case, this part of the behavioral sequence does not pose much of a problem. The opportunity for mutual roosting exists with the simulated habitat approach; it is probably unnecessary if artificial insemination is to be used.

Courtship Feeding should not be a problem provided that (1) the food is not tied to a stump or board, so that the male *can* take it to the female, and (2) the behavior is *allowed* to develop by the female. By the latter I mean that the female be kept adequately fed and/or be previously handled such as to prevent her from immediately stealing the food from the male. One such oversight could stop the sequence. Courtship feeding seemed very important with my kestrels, and I invite you to read about it in the article in *Raptor Research News.* Note particularly its relationship to the pair bond and its copulation-producing contributions.

Many other familiarities seen in the wild are also permitted and have been seen in captive situations; again, in the case of wholly artificial means they appear to be unnecessary. Billing, vocalizations, mutual preening, bowing, nibbling of the feet, and wing fluttering do not present major blocks to the chain of behavior patterns leading to copulation, since they are readily allowed in confinement.

With *cooperative hunting* excursions and *courtship display flights* we run into

problems. They are virtually out of the question in the captive situations. Display flights are important. This can be seen from the facts that (1) courtship flights in many birds are so species- or genus-specific that they are being used in systematic studies of closely related bird groups, (2) birds of prey fall into this category, having quite distinctive courtship flights, and (3) in many cases, as with my kestrels, courtship flight behavior patterns are very stereotyped, a property which is shared by most instinctive behavior patterns. Courtship is instinctive in its basic pattern; and one instinctive behavior often acts as a stimulus for another instinctive behavior.

Assuming that your falcons paired reasonably well, it is possible that inhibition of courtship flights was the pitfall of your project. The external environment was the problem. Suffice it to say that the elicitation of instinctive, sequential behavior patterns will always be a problem, even at the outset of the wholly artificial paradigm.

In spite of the pitfalls and the failures, there have been some successes. In cases where birds have at least produced fertile eggs, they were able to abbreviate their courtship displays. They most certainly performed displays, nevertheless, but adequate courtship is not happening often enough with large falcons.

The Alternative to 'Natural' Captivity Breeding. The bright spot among the failures is the increased interest in artificial means. The disappointment of having a six year old falcon that will attack an old tiercel on sight certainly has led many to ponder the thought of bypassing pairing, and bypassing the territorial aspects of falconiform behavior. This leads directly to the question, "What behavior patterns, natural or aberrant, should be stressed if we forget about pairing bird to bird, and pair birds to man?"

The falconers among us realize the great extent to which falconiform behavior is plastic. We have seen the whole gamut from screamer to seasoned game hawk. As our discussion continues, we should reflect on how individual birds turned out, and how their behavior patterns might be used in captivity breeding. Realize, though, that behavior patterns which are undesirable in a bird used for falconry may be *very* desirable in a captivity breeding program.

As a young falconer I was taught that the only behavior patterns required of a game hawk which were not part of her natural repertoire were (1) for the bird to come down to you out of a tree or the sky, and (2) for her to let you approach her on a kill. Anything more was gravy, or simply unnecessary.

If we reduce captivity breeding to its simplest terms, the only *unnatural behavior patterns* required are (1) for the male to accept a man as a mate or at least as a sexual stimulus, and (2) for the female to lay eggs in a captive situation. As we have seen today, it's not that easy, but there is reason for optimism in both of these situations. Couple (1) and (2) with artificial insemination, and possibly also with artificial incubation and hand- or foster-rearing, and we have a plan of some importance developing.

Summarizing. In summing up, and to emphasize the importance of artificial means, I would like to make the following points.

Simulation of natural nesting conditions in breeding lofts has until now occupied the efforts of many raptor aviculturists. This method has already proved too inefficient to keep pace with declines in wild populations and, as a result of the latter, in the numbers of birds available for captivity breeding and falconry. Unless some breakthrough occurs, we need an alternative to habitat simulation and forced breeding behavior.

Man has been augmenting the productivity of domestic birds for decades by bypassing the necessity of developing complex, copulation-producing behavior patterns. In light of recent successes with artificial insemination with raptors, and assuming that there are far more similarities between falcons and domestic birds than differences, we should place emphasis on behavior patterns which will increase the production of progeny by artificial means. It is irrelevant whether or not these behavior patterns are "typical" of falconiform birds. We should take advantage wherever practical of known behavior patterns of wild birds, but we should not be bound to them in the name of ethology or esthetics.

Contrary to some purists' beliefs, two captive falcons will not a chicken make, either morphologically, physiologically, or psychologically. Such problems of the progeny will be solved when the time comes. Right now we need to *produce*—artificially, if we can, at least for the time being.

TRIGGERS FOR EGG-LAYING

by Frances Hamerstrom

Sean Morris, the brilliant young British biologist, recently told me of his work filming Blue Tits. As he spoke, one thing after another that I had noticed with raptors fell into place: for example, triggers that lead to egg-laying.

The Blue Tit must time its egg-laying so that caterpillars will be available to feed the young. There are early springs and late springs so she cannot use day-length as a guide. She prepares her nest early in the season and then loiters. When the male brings caterpillars to her in large enough quantities she starts laying—having started, she completes the clutch.

Balfour has stressed the close connection between the sex act and food in harriers. In my experience, harriers only breed well when mice are abundant, and furthermore it is my hunch that food is more important than aerial displays in harriers. Recently harriers have been breeding successfully without sky dancing in good vole years. There was one exception: many voles and almost no breeding. I suspect it was the year that they were carrying the highest pesticide residues.

For captive breeding, it appears we do not need all the triggers, but we do want to *time* them. Presentation of food is the easiest of all to time.

Falconers are accustomed to offering food once a day. I can think of few things less likely to trigger egg-laying. Notice I am not talking about availability of food, but of *presentation* of food. A number of species of raptors lay small clutches or fail to breed when food is scarce. When food is scarce it is less often

presented.

Essentially all falconers understand the advantages of tid-bitting in training. Holding half a Plymouth Rock hen on the glove gives at best one flight a day. I am coming back to that Blue Tit female—repulsive as it may be to some to learn from dickey-birders—the Blue Tit lays when caterpillars are *presented often enough.* Let's give our breeding birds the idea that hunting is good when we want eggs. Tid-bit.

Furthermore, a trigger may lose its effectiveness if it is used constantly. I do not believe that my Golden Eagle, Chrys, would have laid six clutches in five years if she had not had frequent nest visits from me just before laying. She did *not* get this kind of attention until I figured egg-laying was near. Like the Blue Tit male, I spent several weeks in lack-a-daisical attention and then pulled out all the stops at once: frequent visits, nest building, neck stroking and using my voice. The most powerful response that she gave was to hay for nest lining. If hay was withheld and then dumped on her nest, she went straight into a copulatory reflex—possibly a releaser for ovulation.

Birds that have stick nests are fascinated by sticks. If you work with them with sticks and are getting along well with them with sticks, tease them—don't always give them the sticks, hang onto the sticks, make it a little difficult for the birds.

As falcons and owls do not build their own nests, they are not apt to be "turned on" by hay or sticks. Old pigeon wings and such may stimulate sex play and ovulation in these groups.

Heinz Meng, when he mentioned how he crouched and ran along outside his falcons' breeding room, immediately struck a bell as far as I was concerned—I think we need to vary things. Which of our breeding birds have a chance to defend their nest? We spare them this as hard as we can. We shy away the public, frighten away the dogs, and even hassle the children. Now, if you let the birds get scared sometimes, maybe it does them good as long as they don't get too scared. Consider this possibility, because then they are defending a nest, which is the natural thing for them to do from time to time.

Many of us are inclined to keep trying everything that we can think of to produce eggs. Perhaps we need to learn to *deny* some of the stimuli for a time. They may work a week later.

It has become plain at this conference that raptors are not strongly determinate layers. To get more eggs—once you have some—two courses are open: keep taking away eggs (I'd leave one in the nest), or take the whole clutch and hope the bird will lay another.

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(Fran's book devotes almost half of its pages to her efforts toward captivity

breeding of her Golden Eagles. During the last several years, she and her eagles have come extremely close to producing captive-bred eaglets by the artificial insemination method. For a fascinating account of the ideas, methods, and techniques surrounding the courtship and artificial insemination of these birds of prey, I would strongly recommend that everyone interested in captivity breeding carefully read this book. And, by the way, it is in its third printing. R.W.N.)

BREEDING BEHAVIOR OF CAPTIVE AND WILD PRAIRIE AND PEREGRINE FALCONS

by Richard Fyfe

Introduction. One aspect of the raptor studies being carried out by the Toxic Chemicals Section of the Canadian Wildlife Service has been field studies of falcon behavior in relation to our pesticide investigations. These studies have been oriented toward documenting normal behavior patterns so that we would be in a position both to identify and interpret behavioral changes observed in the field. Detailed observations have been made on several pairs of Prairie Falcons (*Falco mexicanus*) which were known to be carrying very low residues of toxic chemicals and on one pair of *anatum* Peregrines (*F. peregrinus anatum*) in 1969 and 1970.

In addition to our field work I should indicate that for several years I have tried unsuccessfully to breed both tundra (*F. p. tundrius*) and Peale's Peregrines (*F. p. pealei*) in captivity. The pair of *pealei* laid two clutches of infertile eggs in 1970 and again in 1971. Obviously, since the eggs were not fertilized, something was wrong, but what? Since we had observed that our presence altered the behavior of the birds we felt that it was not possible to observe normal behavior so long as the birds were aware of our presence. Therefore, in 1971 we built two observation blinds and were able to photograph and carry out detailed observations on the pair of *pealei* and on one pair of Prairie Falcons. Fortunately for us the latter pair were successful in producing four fertile eggs, hatching these and raising all four young to fledging.

For this report I have gone through our field notes and have tried to list the main behavior patterns for the Prairie Falcon in the wild, and have compared these with what we observed in the captive Prairies up to the time of egg-laying. I have done the same for the Peregrines, but since we did not have as much information on this species I have also relied on descriptions in "Der Wanderfalk" by Fischer (1968).

The behavior patterns described below and in Table 1 are listed in the order in which they were observed or described; however, each pattern does not necessarily follow in this exact sequence. In some instances several aspects may be ongoing at any one time with variation in intensity depending on the stage of the nesting cycle; for example, courtship feeding, nest display, mating, and male and female nest scraping may all be observed during the same day or series of days.

The observations described were made by Bob Gibbon, Keith Hodson, Tom Donald and myself, the majority of the observations of the captive birds being carried out by Tom Donald and of the wild Prairie Falcons by myself.

Initial Indications of Breeding. Initially, with both the captive Prairie Falcons and Peregrines, our first indication that something was going to happen was "cacking", or territorial behavior, by the male in the case of the Peregrines, by the female in the case of the Prairie Falcons. This occurred from a month and a half to two months before anything else and was the only early indication that something was happening. In the case of the Prairies, about one month later we heard our first "chupping" (February 26). (We do not describe it as "eechipping"; it is not the "eechip" of the Peregrine, but rather a "chup", an audibly different call.) By the middle of the next month everything had gone completely quiet with the Prairies, and as far as we could tell the birds were not paying any attention to one another. Then, very suddenly, we heard the chupping again (April 3), and we then saw what I describe as preliminary pair bond behavior.

Table 1. Observed Courtship Behavior Patterns in Captive and Wild Prairie and Peregrine Falcons.

	F. mexicanus		*F. peregrinus*	
	captive	wild	captive	wild
A. *Attraction of mates*				
m. initially present on territory				
-prominent perching	na	X?	na	X
-visiting potential nest sites	na	X	na	X
f. initially present on territory				
-prominent perching	na	X?	na	X
-visiting potential nest sites	na	–	na	X
B. *Establishing pair bond*				
pair remains on territory	X	X	X	X(F)
aerial courtship				
-mutual soaring	na	X	na	X
-courtship flight	na	–	na	X(F)
-territorial delineation	na	X	na	X
cooperative hunting	na	–	na	X(F)
mutual roosting				
-in territory	X	X	X	X
-at nest ledge	–	–	–	X(F)
m. visits potential nest sites	X	X	X	X
m. wailing	–	–	X	X
m. & f. display at nest together (1)	X	X	–	–
m. tries to attract f. to nest by carrying food to nest ledge	X	X	X	X

	F. mexicanus		*F. peregrinus*	
	captive	wild	captive	wild
m. ledge display	X	X	X	X
f. remains on territory (2)	X	X	X	X
m. brings food to f. (courtship feeding)	X	X	X	X
m. & f. feed on food together	X	–	–	–
familiarities (mutual preening, etc.)	X	–	–	X(F)
C. *Nesting preliminaries*				
f. begging food with much wailing	?	X	–	X
m. begins making nest scrape	X	X	X	X
m. & f. display at nest site (3)	–	–	X	X
f. works on nest scrape	–	X	X	X
mating				
-f. wails	X(faint)	X	–	X
-f. solicits by posturing	X	X	–	X
-following courtship feeding	X	X	–	X
-comes directly from ledge display	X	X	–	–
-following defense of territory	–	X	–	X
-no observed preliminaries	X	X	–	X
D. *Egg-laying*				
f. dozing at length, appears sickly	X	X	X	X
first egg laid, f. shapes scrape	X	X	X	X
noticeably more aggressive	X	X	X	X

m. = male; f. = female
X = observed
– = not observed
na = not applicable
? = not clearly defined
(1) Preliminary pair bond behavior observed in Prairie Falcons.
(2) Female perching near nest site.
(3) Male and female ledge display in Peregrine Falcons.
(F) From Fischer's "Der Wanderfalk."

It is our hope that this table will serve as a rough guide to the behavior patterns which might be expected in Prairie and Peregrine Falcons. Without question, others will be able to add to the listed behavior patterns, and hopefully those with data on other species will also be able to compare their observations. It would seem useful for similar tables to be drawn up for other species, perhaps using the above as a base and merely adding or deleting behavior patterns where applicable.

PRAIRIE FALCONS

Preliminary Breeding Behavior. Preliminary behavior as described for the Prairie Falcon in the literature is listed as aerial courtship; however, other than limited mutual soaring, we have yet to see any aerial courtship in Prairie Falcons in the field. We have seen what we believe was described in the literature; however it was not aerial courtship at all, but rather the interaction between two pairs fighting over a cliff site.

The preliminary breeding behavior that we did observe occurred early in the season as follows. A male and a female visited a series of nest ledges—the male going to the ledge first, then followed shortly by the female. At the ledge they would turn in a small circle, head down and side-by-side, both making the chupping sounds. It appeared that each was trying to force the other one off its feet by what appeared to be one trying to get its head underneath the other's body to lift it up. This they repeated over and over again. In the wild I have seen this behavior only twice (Wayne Nelson has also observed something similar), and with our captive pair we observed this behavior on April 3rd and 4th and then it was all over. Its occurrence was early in the season, was very brief, and was something that could have been easily missed. I have not observed this behavior later in the breeding season and therefore describe it as preliminary pair bond behavior.

Male at the Ledge. The preliminary pair bond behavior seemed to initiate things and was followed by increased activity by the male at nest ledges. Initially males have been observed visiting two or more ledges, looking at them, making scrapes, apparently paying little or no attention to the female and seemingly satisfying himself with the ledges. We have observed this to some extent in our bird in captivity as well as in the wild.

Attracting the Female to the Ledge. Next, in general, the male tries to attract the female to the ledge of his choice by going to the ledge, displaying and calling to the female. This occurs very often in the early phases as over and over again the male goes to the ledge to display and he then comes out to look at the female, or simply stands, chups and then looks up at her. Very often he calls with his head actually face down.

Frequently, in the case of the Prairie Falcons, the males also apparently tried to attract the females to the nest by carrying food directly to the nest ledge, and this in turn signaled the onset of "courtship feeding." The male would take the food to the ledge, get the female to come to him for food, and then take off, leaving her there. These two activities were observed in both captive and wild birds.

Food-transferring. In the wild the male Prairie brings food to his territory, following which the female runs or flies to him, wailing loudly and mantling as she comes. He then relinquishes the food to her when she grabs it, letting go with barely a struggle. However, in our captive pair the male at first would not

relinquish the food and for the most part hung onto it. Sometimes he would just stand there and eat, the female would approach, grab the food as well, and there would be a bit of a struggle. Usually they would end up eating it together, side by side.

Female at the Ledge. At this stage in the wild, occasionally the female would go to the nest ledge of her own accord. Although the male still tried to attract her there whenever she was elsewhere, as soon as she arrived he would take off and leave her, following which she would usually work on the scrape or perch beside the ledge.

In captivity we did not observe the female nest scraping in the early stages.

Wailing. I've mentioned how the female in the wild can be heard wailing. This is incessant, and if you were to visit an area where Prairies are courting you would be able to hear the wailing up to half a mile away whenever the female calls to the male for food or is wailing prior to copulation (copulation most often follows immediately after courtship feeding). In the captive situation we could hardly hear the female as her wailing, though continuous, was very, very faint. This may have been a result of the birds always being so close together in confinement.

Copulation. Mating begins several days to a month or more before egg-laying, and increases in frequency towards the laying of the eggs. (Captive Prairies first mating April 9, first egg April 15.) Usually mating took place in one of the following three sequences observed in both captive and wild situations.

1. Immediately after the male had fed the female and she had finished the meal, she would feak, put her head down and start to call (wailing) to him—he would then come directly to her.
2. The male would be at the nest ledge, the female sitting elsewhere. She would posture and call, and the male would come directly from the nest ledge.
3. Sometimes, with no preliminary that we could see other than the female bowing, the male would come directly to her and mate with her.

The most obvious behavior here was that the female literally postured (or so it appeared) any time the male flew towards or looked at her. I believe she initiated mating by the male in this way.

Often we saw the male simply look towards the female, and her head would go down, she would then posture, head down, wings out—and appeared to solicit the male to come. In the beginning he did not always come to mate, but as egg-laying approached, the mating increased in frequency. The most matings that we have observed in captivity was five times in a single day. In the wild the most that I have observed was three times in one hour. In Peregrines mating has been observed up to five times in one hour.

Lethargy near Egg-laying. Just before egg-laying there is a period when the females appear very sickly for several consecutive days at which time they just sit quietly with feathers puffed out. At this time the captive female was observ-

ed dozing on her perch, and whenever the male tried to attract her attention she appeared to ignore him as if past much of the sexual stimulus.

This was also very obvious in the wild and although I have not noticed the females ignoring the males, I have seen the females perch on cliffs for great periods of time, all the while looking very sickly. This is very obvious in both Prairie Falcons and Peregrines just prior to and during egg-laying.

Egg-laying and Aggression. It was apparent that after the first egg was laid, the captive birds became much more aggressive (Heinz Meng mentioned the increased aggression in his Peregrines before and during egg-laying, and it intensified after the eggs were laid). Our captive male Prairie previously was not aggressive, had always been shy, and was never very tame, therefore, in this case, the increased aggression was quite obvious. Usually aggression in the wild appears to intensify with egg-laying but is not as obvious or intense as observed in the captive birds.

Serious incubation did not start until the last egg, on April 21, with incubation following for 39 days (i.e. until the last egg hatched). We will discuss incubation periods in another panel, but I would suggest that you don't pay too much attention to some of the incubation periods that are listed in the literature for falcons or you could be in trouble.

Differences between Wild and Captive Birds. There were several things which we noticed were very different between the captive and wild birds in the last part of courtship, and in egg-laying. One activity that appeared to be normal to both captive and wild pairs was the male bringing food to the female, or bringing food to the ledge and the female coming for it. In the wild there seemed to be an obvious regularity to much of this behavior. The male would bring food within a set period of about an hour in the early morning, later in the morning, again in the afternoon, and so on. In the captive situation there seemed to be no regularity. Also in relation to incubation in the wild, male and female incubation periods appeared fairly well-regulated, but not in captivity, as our female Prairie simply didn't want to let the male have his turn at the nest for either incubation or brooding. Still another area of abnormal behavior appeared in courtship feeding, as mentioned, when the male was reluctant to give prey to the female. Later we observed the male feeding the female on the nest ledge, also the female feeding the male on the nest. I have seen nothing like this in the wild to date.

PEREGRINES

Early Activities. As mentioned, the first sign we had of behavioral change was "cacking" in our captive Peale's Peregrines–this was also the first indication that they were being territorial and that breeding behavior was beginning. This was followed by an extended period when the male would stand by the wire and wail (the "waaaik" call, which we have also heard very early in the season in the wild). For Peregrines, Fischer lists several preliminary courtship activities:

the attraction of a mate, mutual roosting, courtship flights, cooperative hunting, wailing, and the male moving from ledge to ledge. Some of these aspects we did see in preliminary courtship in our captive birds. We did not, however, observe mutual roosting at the ledge, and I personally have not yet observed this nor cooperative hunting in the wild.

Attracting the Female to the Ledge. Next in sequence is the activity of the male at the ledge, examining ledges and displaying, apparently trying to attract the female. Once again this seems to be very closely tied with courtship feeding. I have observed both captive and wild males carrying food to the nest ledge and the females coming to retrieve it from them. The male actually brings food to the ledge, apparently to attract the female there. Often, as with the Prairies, the male would go to the nest ledge and while bowed, call ("eechip") to the female, very obviously looking towards her, or alternately he would call, turn around, and then go out and apparently look to see if she was attracted. This seemed to be a very definite attempt to attract the female to the ledge and, again, was observed in both wild and captive situations.

Nest-scraping. In our captive *pealei* the male was the first of the pair observed to be making nest scrapes. In so doing he would go to the nest ledge, start bobbing, forming with his body, and foot scraping. (The same actions were used by the Prairies.) The female also made scrapes although generally a little later in the period when visiting the nest ledge.

Copulation. In the wild, we have observed copulation both following "courtship feeding" and following the male and female nest display on the nest ledge. In our captive birds we did not observe copulation, and this is apparently where the courtship broke down. Although lack of mating was perhaps partly the fault of the male, our observations suggest that it was primarily the fault of the female. In both captive and wild situations the male and female Peregrines shared in incubating and had regular changeovers. Also, both birds became aggressive at the onset of egg-laying.

Pairing. Our observations suggest that the preliminary courtship ritual with Prairies and Peregrines may occasionally be extremely short. At some sites we have had Prairie Falcons perching in pairs at cliffs throughout the winter and into the spring, at others lone males at the cliffs and at still others lone females. In the latter cases as soon as the mate arrives everything apparently is "go" suggesting that we have a situation in which we have long established pairs. (To some extent this has been confirmed by trapping and identifying the pairs several years in succession. Contrary to some of Jim Enderson's early findings in Colorado, we have found that our Prairies are staying with the same mates at the nest sites.)

To be more specific we have examples in which we have been watching an individual Prairie Falcon at a cliff for a week or more when suddenly a mate

arrives and the same day they have been observed copulating. There appears to be little or no preliminary activity in such cases.

Similarly with Peregrines, we watched a cliff for two weeks, on which the female was back first. Her mate from the previous year did not return, but a new male did, and, again, on the first day he was there they were observed mating. It is therefore not clear just how necessary some behavior patterns are, particularly the preliminary ones such as courtship flying.

Failure at Copulation. We feel there are several reasons why we did not get copulation in our captive Peregrines. One obvious observation was simply that our female Peregrine at no time solicited the male. On one occasion we did observe her bowing, but when the male came toward her there was no posturing. The male was observed on at least four occasions to attempt copulation, i.e. he tried to mate with the female; on only one occasion did we see her head go down, but that was all, and the male was not allowed to mate with her.

To further complicate matters the male apparently was afraid of the female (something that we found rather difficult to tell with certainty). Several times, for example, we observed that when the two were sitting close together, if the female turned toward the male he would immediately back off or fly. Also several times we observed him backing away from her when she approached. As a result of these and other observations we believe that the male was definitely afraid of the female. At no time did we observe familiarities (billing, preening, etc.) described by others for Peregrines and observed with our Prairies. All of which suggests our pair were not truly compatible.

These are some of the factors which we feel prevented copulation and prevented us from getting fertile eggs with the Peregrines, in contrast to the captive Prairies, which were compatible, mated, and from their first clutch raised four healthy young.

Blinds for Observing Behavior in Captivity. Initially it should be noted that with regard to our captive Peale's, because the female was laying eggs we believed that she was ready but the male was not. If we had not had the blind there is no way we would have realized that the lack of fertilization may *not* have been the male's fault since we could not have assessed this without seeing what the birds were doing. The preliminary activities, vocalizing, and egg-laying apparently do not necessarily tell the whole story.

A blind allows you to see everything that is happening. With the Prairies we photographed and observed mating at about 12', and Tom actually watched the female laying the individual eggs. We therefore knew what was in the nest and what was happening at all times. Some of the activities occur so briefly that unless you can spend a considerable amount of time watching you may very well miss some of the important things. Nevertheless, with some record of sequence of behavior patterns it is possible to watch for and see the more important aspects.

If you establish a blind, don't be too alarmed if at first you notice that your birds are a bit upset every time they hear you, because they probably will be, and may take a few days to adjust. However, after about a week they just seem

to forget about you. We found that we could talk and do almost whatever we wanted in the blind. However, watch cigarettes, lighted matches, cigarette lighters or flashlights in the blind because these bright lights can be seen through the mirrors. It is absolutely necessary to keep the inside of the blind at least twice as dark as the outside in order for the mirrors to function.

Distractions. In apparent contrast to the adjustments the birds make to sounds, we have noticed that the captive birds are easily distracted visually. With our Prairie Falcons, when they could see out of the building, any sudden movement would make them cease whatever they were doing. For this reason we covered one end of the building with fiberglass, and immediately activities proceeded without disturbance. Noises do not seem to bother the birds to the same extent, whereas we felt anything new visually was a very definite distraction to them.

Disturbance, Desertion, and Damage to Eggs and Young through Visits and Gunshots. My data from the field suggest that visits to eyries or the vicinity of eyries immediately prior to egg-laying or at about the time of the first or second egg may be very critical and the birds will readily desert. In contrast, once incubating, the falcons at least will take a considerable amount of human disturbance. (This appears to vary with individuals, and tolerance may be influenced by toxic chemical residues.)

Also in relation to disturbance, one aspect that we observed will be of importance to anyone working in the field. We noticed that if a person comes to an eyrie unobserved by the incubating bird, even while talking and making noise, the bird will remain tight on the scrape. This holds true most often with Peregrines, Prairies, and Golden Eagles, so that the incubating bird usually remains on the scrape until it actually sees the intruder. Even if one bird is flying around making a great racket, the other will usually sit tight, with the result that on sighting the intruder the incubating bird springs from the nest. Since in incubating eggs or brooding the small young, the adults work their feet under and between the eggs and/or chicks, when startled off, these may be thrown up to four feet from the scrape. We have observed and photographed the results, and actually have pictures of eggs and chicks three to four feet out in front of the scrape. We have also come to a cliff and have seen a chick go down to its death just because the brooding bird was startled, even though there was talking and noise from above to warn the adult. I suggest that anything which startles the bird on the nest with eggs or small downy young is actually endangering those eggs or chicks. As mentioned, the eggs and small chicks apparently are resting on top of the adult's toes and tarsus, and may be flung out as the adult flushes. If the ledge is wide enough, and not of jagged material, this may not be too serious since the falcons can roll the egg back, or they will go as far as three and four feet and pick up even a day old chick and carry it back. Nevertheless the danger is a very real one, and I have recorded the results over and over again.

On the brighter side, we have also been able to observe the results when one approaches directly so that the birds can see you coming. First they sit up to

look at you, then raise, and finally stand. They, therefore, are able to leave the nest when they want to, not when they have been startled.

For people doing surveys I suggest this is a very real concern. If you are firing guns at cliffs, or if you are going to the tops of cliffs and looking over, when there are eggs or small young, you are risking the possibility of cutting down production by one or more, depending on how often it happens. We have recorded these results, and I mention them because it was a real shock when we realized just how frequently this occurred.

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IMPRINTING, AND OTHER BEHAVIORAL CONSIDERATIONS

by Wayne Nelson

Introduction. The discussions of *imprinting* at this conference were, to this observer, among the most important. Many of the egg-infertility problems may be solvable by carefully considering that aspect of behavior. I will attempt to throw some more light on imprinting and its problems at the end of this section.

This report is not a written account of my presentation to the conference; rather, it is an attempt to synthesize and evaluate some of the discussions and some of the questions which arose and which were concerned with the behavior prior to and during egg-laying.

(An outline of courtship behavior in Peregrines (*pealei*) in the wild was presented to the conference, with 35 mm slides and 16 mm film. From this it is hoped that the audience received a "feel" for the type of behavior patterns which normally lead up to egg-laying in the coastal Peregrines.)

Based upon the courtship behavior seen in wild Peregrines, a discussion and a number of suggestions for captivity breeding have been presented (*Raptor Research News,* March-April 1971). That article considered a variety of factors which appeared to be of importance to captivity breeding—e.g. spacious ledges of a variety of types; one-way glass for viewing undisturbed behavior; avoidance of disturbance; necessity of water at laying and hatching. Several further points must be added to that article's discussion.

Some Behavioral Considerations. 1. *Aggression.* Heinz Meng described at this conference how he "encouraged" his tiercel Peregrine to "defend" the breeding chamber. Dr. Meng would run, crouching, past the chamber, and the tiercel would chase along the ledge inside the windows of the chamber. (This pair of Peregrines was given food through the windows of their building.) This situation is very similar to what sometimes occurs in the wild coastal Peregrines; prior to egg-laying one or both adult falcons sometimes, for no apparent reason, sudden-

ly will fly up to a quarter mile from their cliff to harass viciously a perched Bald Eagle. It may well be, as Dr. Meng suggested, that stimulating aggression (NOT fear) may increase the pair-bonding of these birds—in captivity and in the wild.

2. *Disturbance.* There is a very definite difference between aggression and fear, between the response of a bird to a distant intruder and to an intruder which is at or in the eyrie. At the conference a number of interesting observations were reported.

(a) R. Fyfe described how captive Prairie Falcons (being watched from a blind) ceased their courtship activities when human beings or other animals were in view in the yard outside the breeding quarters; a translucent divider, obstructing the view of outside activities, allowed the birds sufficient privacy that their activities were not subsequently interrupted. These birds and others became very accustomed to sounds in the nearby area and from the blinds from which the birds were being watched.

(b) Maj. R. Graham told how a captive Peregrine laid a clutch (which was removed), then recycled. At the time when the second clutch was expected, the falcon's abdomen distended somewhat, indicating that the first egg of the second clutch was soon to be forthcoming. He felt that his visits to the nest ledge, several times per day, prevented the falcon from laying that egg (and the second clutch), and that it had been absorbed.

(c) G. Galicz noted one instance in which his Peregrines' breeding quarters was visited on one day—on the same or the following day an egg with no shell was laid. He suggested that the disturbance of the visit might have caused the production of the abnormal egg.

In view of these and other observations, it would seem wise to avoid entering the breeding quarters occupied by a defensive (territorial) pair, especially just prior to and during the laying of a clutch. Other means are available for checking on egg-laying.

3. *Food-transferring and Diet.* A plentiful supply of food appears necessary for egg production. In a variety of raptor species it has been observed that the males usually eat the heads of prey items before giving the food to the female or nestlings (Osprey—Ames 1966; Cooper's Hawk—N. and H. Snyder, this conference; European Sparrowhawk—Herren 1970; Peregrines—Nelson 1971; and others). While the reason for this is not yet obvious, it appears to be of some importance—and it suggests that we might be wise to avoid giving our captive birds such unnatural diets as strictly or largely heads and necks. It is possible that extra-thick eggshells are resulting from diets heavily laden with calcium (bone), and that a few instances of nestlings dying upon hatching may be due to difficulties in breaking out of very strong eggshells.

4. *Vocal Stimulation from Nearby Pairs.* From the behavior and laying dates of wild Peregrines I have found no suggestion that the sounds (or other activities) of one pair either stimulates or inhibits the breeding of nearby pairs.

5. *Lighting.* There is some suggestion that clutches laid in the late spring or early summer may be due to relatively poor lighting within the breeding quarters. Some pairs which lay infertile first clutches (followed by fertile second clutches), and some pairs which refuse to come into *any* breeding condition, may be doing so because of various degrees of inadequate light stimulation (see Koehler 1969). Observations of the behavior of such late-laying or non-laying or infertile clutch pairs could indicate what their difficulties are—and observations made on them when brighter lighting is provided should give additional suggestions as to why these birds are behaving abnormally.

6. *Photoperiod.* Numerous writers in *Raptor Research News* and elsewhere have indicated the importance of long daylength and changing daylength upon captive raptors. The general lack of courtship behavior reported for tundra Peregrines (and Gyrfalcons) is obvious (see BPIE reports). One means of stimulating courtship (and egg-laying) in these birds, that apparently has not yet been attempted seriously, is that of giving the captive northern birds a photoperiod regime which follows as closely as possible the changes which the birds in the wild would receive—*not* simply giving them a long day-length only in the spring and summer, but giving them a *changing* photoperiod which judiciously *duplicates* that which the birds are seeing in the wild. This method *must* be tested, since all other methods appear to be failing with these northern birds. I hope to be able to expand on these thoughts at a later date.

7. *The Variety of Repertoires.* It seems fairly safe to say that no two pairs of birds will necessarily behave in an identical manner. Variations in behavior, leading to the same results, need not be considered as signs of gross abnormality. Fyfe (this conference) noted a number of similarities and differences between the behavior of wild and captive Prairie Falcons; in general the results were the same—e.g. in captivity the male may hang onto the food when he brings it to the female, but she gets food from it whether he gives it to her or whether they feed from it together; both male and female may incubate, side by side, but the eggs get incubated.

Also, it should be remembered that the birds may have to "learn" how to carry out some of the more intricate behavior patterns—e.g. they may have to "practice" a number of times before being able to complete copulation; the *first* feeding of the nestlings may be very clumsily carried out by the female. Don't panic if the birds do not do something correctly or perfectly the first time you see it.

IMPRINTING AND CAPTIVITY BREEDING

by Wayne Nelson

Introduction. To this writer, one of the most potentially useful concepts to fall into place at this conference concerned the imprinting of captive breeding stock. For the most part in the following discussion I will be considering the

larger falcons, but many of these observations and suggestions undoubtedly are applicable to other species. (I must thank Butch Olendorff for providing me with the initial stimulus which has brought the following thoughts and observations to the surface in my mind. While little of the following discussion is original information, the way it all fits together does fall into the category of—"How foolish of me not to have thought of that long ago." Because many captive breeders have not apparently seen the problem in this way, I am going to treat it in some depth.)

Two Types of Captive Birds. By observing the courtship behavior of the captive birds we should be able to recognize two types of birds:

1. those birds which are imprinted to their own species, and
2. those birds which are imprinted to human beings.

The former type, if given reasonable facilities, minimum disturbance, adequate lighting and photoperiod, etc., should be capable of breeding on their own. The latter type (imprinted to human beings) will possibly *never* "revert", never complete a courtship phase with a natural mate, and never produce a fertile clutch; they are probably good for only one thing—artificial insemination reproduction—and they should be very good for that. There may be some gradation between these two types, and there may be some reversibility of the imprinting in either direction. I would guess that the majority of the captive birds taken as eyasses fall into the latter category—imprinted to human beings.

From a hurried review of some animal behavior literature, it appears that little is known about imprinting in birds of prey. Konrad Lorenz (1937:263) noted:

> "Heinroth failed to breed hand-reared Great Horned Owls, Ravens and other birds, for no other reason than that these tame individuals responded sexually to their keepers instead of to each other. In a very few cases known, the bird whose sexual reactions were thus directed toward man, finally accepted a fellow-member of the species which, however, was always regarded as a rather poor substitute for the beloved human and was instantly abandoned whenever the latter appeared."

Mendelssohn and Marder (1970), in discussing captivity breeding problems, pointed out:

> "One of the reasons for lack of success may be that one or both partners may be imprinted on humans. Many birds of prey kept in captivity have been taken from the nest as young nestlings and been hand-reared. If they are reared without the company of conspecifics, they will, if young enough, develop imprinting on humans; the human companion will be accepted at first as a parent companion, later as a social companion and eventually as a sex companion (Lorenz, 1935). A bird may remain imprinted for many years or even for life. Young owls may become imprinted on humans until a relatively late age, since with these species identification of the companion seems to be visual, and visual

> acuity develops in owls only after their intermediate plumage has grown. . . . Sometimes even rearing owls together with conspecifics does not prevent their becoming imprinted on the human foster parent (Heinroth and Heinroth, 1926)."

Age of Imprinting. Most readers are probably aware that at a very tender age (hours) ducklings, geese, chickens, etc., will fixate onto nearby moving objects (sometimes the appropriate sounds must be given, also) and exhibit the "following response" (a form of imprinting) in which the object—person, wagon, mother bird, etc.—is followed and treated as the mother bird. In birds which are not mobile soon after hatching, and which may even be blind for some days, the imprinting process does not occur until a later date in the nestling's life.

In the birds of prey it apparently is not yet clear exactly when the critical period occurs, when the young birds acquire the "image" of their species, their parent, and the features of their future sexual partner. There are some good hints as to when this occurs, however.

McElroy (1971, and various *Hawk Chalk* articles) has described behavioral differences between the "imprint" and the "brancher" in Cooper's Hawks trained for falconry. The "imprints", taken from the nest at about 18 days or less remained relatively tame, whereas branchers (fairly well feathered, quite mobile but not quite flying) never became very tame and were almost as difficult to train as wild-caught passage (migrant young) or adult Cooper's Hawks. In general terms, with some adjusting due to differences in the rates of development, this situation probably applies throughout the raptors.

In the Blond Ring Dove (*Streptopelia risoria*), Klinghammer and Hess (1964) conducted experiments to try to discover when the critical period for imprinting occurred. These doves first fly at about 14 days of age, and are fed by the parents until at least 21 days of age. They were tested when about 10 months old to see whether they would choose another dove or a person as a mate, after having been reared under a variety of conditions (naturally by the parents, hand-reared and isolated, etc.). The optimum imprinting (to people) was found to occur when the young doves were taken from the nest and reared by people at 7-9 days of age. If taken when somewhat younger, the doves were slightly less predictable in their choosing between a human and a dove for a mate. If taken when older than nine days, the doves usually chose another dove instead of a person. In isolated doves, which saw no other doves and saw only a man at feeding time and when pens were cleaned, the imprinting to people was more likely to occur. Some doves, even having been imprinted during infancy to their natural parents, did show some imprinting to people due to *association* (admittedly brief) through their life in isolation. This study of imprinting in doves may be the closest thing with which comparisons can be made with raptors. If the general situation of imprinting in doves sounds at all similar to some captive breeding attempts with raptors, I do not think it is coincidental. Indeed, it seems probable that many or most of the captive breeding stock, which we are trying to get to breed with a mate of their own species, are actually imprinted to human beings.

Some Successful Breeding Attempts. Following from the suggestions seen in the above information, *does it seem entirely coincidental* that:

1. Renz Waller's twice successful Peregrines (1942 and 1943) involved a female of unstated age and origin and a *wild-caught adult* male? (Waller, 1968.)
2. Philip Shultz's *haggard pair* of Prairies laid eggs in 1971 (one clutch of four, infertile however)? (Shultz, BPIE 35, *Raptor Research* 6:31-35.)
3. Richard Fyfe's successfully breeding Prairies (first clutch in 1971 hatched all four eggs) were taken from the wild as "five week old eyas" (male) and "four or five week old eyas" (female))? (Fyfe, BPIE 36, *Raptor Research* 6:35-36.)
4. Heinz Meng's successfully breeding Peregrines (*pealei*) (second clutch in 1971 hatched all four eggs) were taken from the wild when "*they were almost branchers*"? (Meng, BPIE 30, *Raptor Research* 6:25-28.) (Emphasis is mine.)

The ages of capture of Beebe's (1967) Peregrines (fertile eggs, 1967), Schramm's successful Peregrines (Peterson 1968), and Kendall's (1968) and Enderson's (1971) successful Prairies were not specifically stated in their reports.

Some Apparent Contradictions. In American Kestrels it has been shown in several instances that some hand-reared eyasses (even reared from eggs) eventually pair with their own species (Koehler 1969, Porter and Wiemeyer 1970). Porter and Wiemeyer (1970) mentionssome deaths of male kestrels which were caused by their female partners, but the histories (backgrounds) of those birds were not specifically stated.

The Captive Imprint. There are two situations in which "imprints" are found in captivity. The first situation involves imprinted birds which *we* do not realize are imprints because they are in a paired captive breeding effort. The second involves birds which in general are held singly, and which show signs (sometimes) of broodiness and probably courtship toward man, especially in spring. (Throughout these discussions I am using the terms "imprint" and "imprinting" rather loosely, mainly because I have been unable to find an adequate definition for these terms as they apply to altricial birds.)

1. *The Imprint in a Pair.* Probably most eyass-taken falcons (of the large species, at least) in captive breeding projects fall into this category. The two sexes probably show little interest in each other; the female probably dominates at feeding time. They both may become breedy, noisy, and very defensive in the spring, and infertile clutches (even after recycling once or twice) are the only result. They make good foster-parents as a rule.

Their apparent compatibility, their sharing of defense, incubation, and foster parent activities, and their disrespect toward human intruders in their room—all this does *not* tell you that they are paired, and it does *not* tell you that they are not imprinted to human beings. In fact, if the female does lay eggs, it tells you

that (a) your conditions are extremely close to producing fertile eggs, or, more likely, (b) your conditions are reasonably conducive to reproduction, but those birds are indeed imprinted to people and not to their own species.

a. An apparent example of an imprint in a pair. By watching the birds (see below for methods) during the courtship phase you should be able to determine if the pair has formed a pair-bond and is in fact *cooperating* in their activities.

Fyfe's observations of the point of pair break-down in his Peregrines are very significant (Fyfe, BPIE 38, *Raptor Research* 6:38-39, and this panel report). This pair in 1971 showed most of the expected courtship activities. But, at the point several weeks prior to egg-laying when copulations should have begun, this pair failed; the female failed to respond to the approaching male. Had she responded to the stimulus "Approaching Male Peregrine," she would have bent forward into the copulatory posture. The male would then have been able to alight on her back, and copulation could have been completed. This female laid eggs—obviously she was sufficiently stimulated by the other features of the captive environment, and she even recycled when the first clutch was removed. She was sufficiently stimulated for egg-laying to occur—but the male apparently was the *wrong* stimulus for the final and most essential behavior pattern—copulation.

b. Possible solutions to the problem of imprints in pairs. Assuming that the captive breeder desires progeny from his birds, and assuming that he has spent some time watching his birds and has seen no sign of copulation nor any sign that it might occur, what should he do?

(1) The arrival of the first egg is probably the first positive sign that we can react to. At that point, entering into the breeding room (perhaps at night), capturing the birds, and utilizing (rough) artificial insemination (A.I.) methods may be the only means of acquiring some fertile eggs in the first clutch. (In other words, one should have practiced A.I. beforehand to be prepared.) Handling of the female (with a partially-formed second egg within) would have to be carefully done. Candling of eggs at about 10 days of incubation should show whether or not fertility was achieved.

(2) The breeder could observe the behavior of the pair through the laying of the first clutch, and positively discover whether copulations were occurring, whether the male was just a few weeks slow (e.g. due to insufficient light stimulation), whether the female was not responding to his approaches, or whether he was not responding to her solicitations. Candling of the first clutch after about 10 days of incubation should confirm the infertility of the eggs, and removal of eggs should cause the birds to recycle.

This may be a very appropriate way of *synchronizing* the pair—causing them both to incubate for a spell, and develop the appropriate hormonal and behavioral responses, then stealing the eggs so that they *both* start *from that point* into the processes toward egg-laying and sperm production. Recycling could be expected to take about two weeks. (When recycling, one should be certain the female has an adequate diet and a supply of clean fresh water at all times.)

At about the 12th day after the first clutch was taken (this length of time appears to be fairly variable), if she is going to recycle, the female should again

enter into "egg-laying lethargy." Again, by observing over a number of hours (read a book behind your one-way glass if things are not too active in the bird-room), the person should attempt to confirm that the pair is indeed incompatible, that copulation is not occurring. At this point, or immediately after the first egg is laid, A.I. methods could be imposed upon the birds, to attempt to obtain fertile eggs in the second clutch.

(3) A possible (but considered unlikely) long-term solution might involve attempting to leave the two imprinted birds entirely isolated from people for a long period of time, feeding and watering them via trap doors, or in absolute darkness. There is a possibility that, lacking any reinforcement of the imprinting to people (that is, no person presenting food, etc.), the birds might "revert" back, might successfully mate with the other bird in the enclosure. Aside from a small number of instances with kestrels, there does not seem to be much suggestion that such reversion will occur in other species.

2. *The Imprint as a Companion = the Human Being as a Bird's Mate.* This method appears to offer the best means whereby the imprints can be brought into productivity. It takes some time, effort, and devotion to the cause—but these are some of the usual characteristics of the people involved with captivity breeding.

Apparently this method has not yet been seriously attempted with the falcons. Olendorff's comments on the Behavior Panel of this conference certainly apply at this point.

This method has been very seriously attempted for several years, with some success, by Fran Hamerstrom (1970) with her Golden Eagles. In 1970 Bob Berry got fertile eggs from his Goshawk by this method. In 1971 Stan Temple got fertile Red-tail eggs, and Bob Berry was completely successful with this method, getting three full-grown youngsters from his Goshawk "pair."

By pairing the imprint with a human being over a period of time (manning, handling, etc.), and by manipulating photoperiod, nest or ledge materials, food availability—the human mate should be quite capable of synchronizing the potential breeders, which, of course, should be very definitely separated, lest they kill each other fighting over possession of the shared human mate.

The A.I. involved actually has two possible techniques: (a) massage = rough A.I. (also required for the imprints which are in pairs and are fairly wild), and (b) cooperative technique—in which the bird attempts copulation with the human mate, and semen is cooperatively received from the male and shortly afterwards transferred via syringe to the copulating female. Various degrees of gradation between these two methods are possible and sometimes necessary (e.g. with eagles)! We certainly look forward to detailed reports on the recent progress with this most promising method.

Prolonging fertility for A.I. One behavioral aspect mentioned above merits repeating in this slightly different context—this concerns the means of prolonging semen production in the imprint male. To get the female to again produce eggs we simply have to remove her clutch relatively early in incubation (if taken late in incubation, the recycling period may be longer and less likely to occur).

The length of time the male bird of prey is actually producing semen is not known to this writer. It may be only a matter of several weeks or less. If the first (presumably fertile) A.I. clutch is to be removed to an artificial incubator in order to obtain a second clutch, by that time the male may have "dried up" as far as semen production is concerned. He may still be copulating with the human mate, but his semen production may have ceased (we definitely need some more information on this aspect of A.I. with raptors). And, in fact, the male may have been somewhat out of phase with the female (either ahead of, or behind her) for successful A.I. of the first clutch with his semen.

Syndhronization of the separated pair might be brought about through causing the female to incubate her first clutch for 10-14 days—and getting the male also to incubate at this same time. The male might require some preliminary courtship and nestbuilding play activities with the human mate, but he should be motivated and prepared to incubate if he is provided with a nest and nest materials just prior to when the female begins laying. When she has begun laying the male could be provided with eggs for his nest (perhaps chicken eggs, tinted to roughly match his species' egg color). Once the female is laying, the need for his semen diminishes. With eggs in his nest, and perhaps with some help from the human mate, he should begin incubating those eggs, just as the female incubates the ones she has been laying. With both sexes incubating at the same time, presumably they will be rather closely synchronized, hormonally and behaviorally, even if they were out of phase prior to egg-laying. After both have been incubating 10-14 days (this would allow candling of the female's clutch, and would allow both to become firm incubators), by taking away the eggs from the male and the female (perhaps from the male a day or two earlier), it might then be possible to have the pair perfectly synchronized in egg and semen production, so that in the second time around the human intermediary could ensure successful A.I. of the second clutch.

Another possibility exists for those birds which are held under artificial light. This method involves simply finding and keeping the birds at the photoperiod at which they produce eggs and semen. These methods are used to some extent with domestic poultry (I have not checked into the details with poultry). In Slate-colored Juncos (*Junco hyemalis*) trapped in Illinois on migration, Wolfson (1959) found that a day of 12 hours light—12 hours dark prolonged testis activity for about nine months. Schwab (1970), with European Starlings (*Sturnus vulgaris*) from California, prolonged sperm production in these birds for over 15 months by keeping them at either 10.5 hours light—13-5 hours dark or 11 light—13 dark. He found that 12 light—12 dark did not cause those starlings to continue sperm production for a long period of time. In natural conditions in California the starlings produce sperm for perhaps three months.

With raptors from various latitudes, of course the day-night ratio would have to be modified slightly to keep the birds producing semen and eggs. This method holds considerable promise for producing multiple successful A.I. broods per season. Until we know more about the effects on the birds of such prolonged stimulation, it might be very wise to give the birds some months each year in which they are not subjected to the demands of the breeding season.

The Captive "Non-imprint." When a pair of birds has been taken from their parents late in nestling life, beyond the major imprinting period, their chances for successful captivity breeding should appear to be very great—provided that (1) the pair is given appropriate and sufficient stimuli in their quarters, and (2) they are not imprinted to human beings through frequent or constant association such as at feeding times (remember that imprinting may not be confined solely to the "critical period" of nestling life, but may also occur by "association" through life). The same general situation may hold true for passage and haggard birds, in which cases the minimizing of disturbances may be extremely important.

Knowing the histories of the pair should give the person a good idea of whether the birds are imprints or not.

Candling of the first clutches of such birds (*any* breeding birds) for fertility is essential, unless successful copulations of the pair have been positively observed. If first clutches are infertile, the birds should be forced to recycle if at all possible, so that by the arrival of the second clutch (or third) the male might be sufficiently stimulated by the external environment that he might do his part. This allows the observer more time in one season in which to determine whether the behavior of his pair is appropriate, whether they are indeed "non-imprints."

Caution. Some care must be taken so that misinterpretations of the efforts of the breeding pair do not occur in the *human* mind. There is a definite likelihood that if the lighting is insufficient, the female will be farther advanced than the male, that copulations will not be seen until near the second or third (?) clutch—until the male becomes sufficiently stimulated or becomes synchronized with the female (see Koehler 1969). Some caution must be exerted here, so that the "case" is *not* incorrectly "diagnosed"—so that a case in which the male is insufficiently stimulated (e.g. by poor lighting) *is not incorrectly diagnosed* as being a case in which the male is imprinted to people. To avoid making such a mistake, and blundering into the breeding quarters during the laying of the first clutch to attempt A.I. at that point, it would seem wisest to watch closely the birds' behavior through the laying of the first clutch, and through the first 10 days or so of incubation, then steal the clutch and watch their behavior as the second clutch nears its time of laying—to learn positively whether the pair is in fact cooperating in their activities, to learn whether copulations are occurring or are being attempted.

Foster-parent Problems. Too little experimentation appears to have been done to date to be certain of the effects of foster-rearing on potential captive breeding birds. What good is a Prairie Falcon for captive breeding if the bird was reared by, and is imprinted to a Goshawk? It might be wise to use rough A.I. in such situations, but the problem would be less difficult if the Prairie had never imprinted to another bird species but had imprinted to man instead—or better yet, to Prairie Falcons. And think of the poor bird if it should ever be lost into the wild—trying to court a wild Goshawk! Foster-rearing by a different bird species may well create more problems by imprinting than it will solve. The scientific literature concerning imprinting in waterfowl illustrates some interesting

examples of similarly very confused birds.

Watching the Captive Birds. It is obvious from the foregoing that a number of problems in captivity breeding are solvable if the behavior of the birds is observed in the courtship phase. In the larger species at least, it is unlikely that the birds will be seen to do much of anything if the human observer is at all obvious (even through small peepholes) and within any reasonable distance. The courting birds seem to be rather shy.

How to watch. One-way glass (two-way mirror) is the obvious answer to this problem. While there was some criticism of one-way glass at the conference, it definitely has been shown by a number of people to be very useful (with wild and captive birds), as long as (1) the glass is aimed in such a way that the birds cannot see their reflections in it, and (2) the person is on the darker side (it should be almost twice as bright on the birds' side—otherwise they may see you through the glass). Richard Fyfe has mentioned seeing a lighted match and a glowing cigarette *through* a "mirror" in a store. Presumably birds could be distracted temporarily by such activities behind the one-way glass.

At first the observations from behind the viewing port should not be very regular if there is any chance that the birds can hear the person there, or when arriving or leaving; the first visits should be irregular and of varying lengths so that the birds are unable to establish any regularity of sounds outside the enclosure. Ideally, they should be accustomed to sounds from the nearby area so that they pay no attention whatsoever to them. The quiet sounds of a radio, on and off during the day at various times during the year may condition the birds to expect any type of sound at any time from outside their breeding quarters. In this way, the sounds made by the watcher would in no way inhibit the birds from carrying out their normal daily activities and courtship activities.

What to look for in the pair. The various behavior patterns—or the lack of them—are the keys to solving the imprint–non-imprint problem. Of special interest should be those behavior patterns associated with the nest. Which bird does the building or nest-scraping? Which spends time perched at the nest? Do they perch close by one another? Which dominates at feeding? Does the male *take* food to the female? Do they attempt copulation?

In some species we now have at least an outline of what behavior patterns can be expected and in roughly what order they might be expected to occur. Among the outlines of courtship behavior which we have at present are those of the kestrel (e.g. Olendorff 1968), Prairie Falcon (Fyfe, this conference), Peregrine (e.g. Nelson 1971), Golden Eagle imprints (Hamerstrom 1970), Goshawk imprints (Berry 1968, 1970, this conference), and others. And certainly there are a great many clues and observations scattered through many of the BPIE reports and *Raptor Research News* articles for those who will reread them.

As our knowledge of raptor behavior increases, we will inevitably be able to shed light on more of the problems in captivity breeding. The assistance of all of the people involved with captivity breeding projects, in making a few notes a day on the *undisturbed* behavior of their birds, would undoubtedly be very helpful in the future in solving problems which we cannot yet see.

Summary and Conclusions—Imprinting. 1. Probably most eyass-taken raptors are imprinted to human beings; possibly some passage- and haggard-taken birds are also imprinted to people due to frequent association with man.

2. It seems to be very unlikely that an imprinted bird in a pair will ever breed with its feathered companion; the imprints consider human beings as "their species", and only human beings are likely to be considered as potential mates.

3. The age at which imprinting occurs in a nestling raptor is apparently not yet known; some evidence suggests that the critical period extends to ¾ of the fledging (flying) age; *pealei* fly at 41-43 days of age—imprinting might be expected to occur in this subspecies up to 30-34 days of age, the point when the nestlings are really beginning to feather out all over.

4. By observing the *undisturbed* behavior of a captive pair during the period of time prior to egg-laying, the behavior patterns should tell the observer whether the birds are imprinted to their own species (i.e. they are attempting to cooperate in their breeding efforts), or whether they are imprinted to man (i.e. they are ignoring each other, or refusing to complete the courtship and mating behavior with each other, and generally appear to be attempting to breed separately).

5. The behavior patterns which will provide the best clues for solving the imprint-or-non-imprint problem will be those concerned with the nest, food (sharing), and especially copulation.

6. Several possible solutions to the problem of imprints in pairs are discussed: (1) rough A.I. in the first laying; (2) (best short-term solution) rough A.I. just prior to, or during, laying of second clutch; (3) (least likely to succeed) leaving the pair together in total isolation for a long time (years), hoping that they might revert, or lose the imprinting to man, and mate with their feathered companion.

7. A.I. appears to be the only means whereby imprints will be brought to breed successfully. The cooperative A.I. technique with tame and manned birds appears to offer the best opportunities.

8. Some *caution* must be employed so that some non-imprints (which are insufficiently stimulated by a poor captive environment) *are not incorrectly classified* as imprints; behavioral clues are suggested.

9. Rearing birds with foster parents of another species may cause many difficulties due to the nestlings probably imprinting to the species of the foster parents, rather than to man or their own species.

10. It will be by *watching the undisturbed behavior* of the captive pairs that we will really begin to understand what their problems are, and why some of them are not breeding in captivity.

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APPENDIX: USING CLOSED CIRCUIT TELEVISION FOR THE OBSERVATION OF RAPTORS IN CAPTIVITY BREEDING PROJECTS

by J. Gregory Thomas

The use of closed circuit television for observation purposes in a captivity breeding project can yield several substantial benefits to the researcher. First, the quality of the observation can frequently be enhanced. The silent video camera will not annoy or otherwise disturb the subjects of the observation. Hence, observed behavior should be more truly reflective of the raptors' reactions to each other and to their physical surroundings. Possibly, the researcher would then have the information needed to alter pairing of the raptors or to make a change in some physical parameter of the experiment that would lead to both breeding success and a better understanding of why or why not success was achieved. Second, with the addition of video tape recording equipment, the **amount** of observation the researcher could reasonably be expected to do can be greatly increased. In the terms of the statisticians, the "sample size" has been enlarged. This should help to improve the accuracy of conclusions drawn from the observations. Third, another important benefit comes with the use of video tape recorders. Observations can be saved and stored for later reflection and study. Also, the observations may be shared with other researchers. This would give a heretofor unknown depth to communication between researchers. It might also aid in preventing costly and time consuming "reinventing of the wheel." A more detailed discussion of the costs, techniques involved, and benefits to be derived follows this introduction. Systems and accessories both simple and complex will be included.

Preliminary Remarks. Most video equipment within a reasonable price range is of Japanese manufactore. Experience in selling and servicing such equipment has led the author to believe that it provides good to excellent results for a relatively small outlay of money. It is used extensively throughout educational institutions and in the business community. Therefore, it is sometimes possible to pick up good used equipment at only a fraction of the original cost. The key to getting a good buy in new or used equipment is to have access to a quality video dealer who can both advise on hardware selection *and* service it. Between five and ten percent of the initial investment on any video gear should be allowed for maintenance each year. Because of cost considerations, only black and white systems will be considered in this paper.

Briefly, other considerations that should not be overlooked include the following. Cable runs between cameras and display and/or recording gear shouldn't exceed one thousand feet. Longer distances often require the use of expensive line amplifiers. The general physical environment of the camera should be dry and have temperatures not below 32 degrees F or above 100 degrees F. Deviations from this will usually require the use of special environmental enclosures. Because of the high light levels used in most breeding chambers, light is rarely a problem. However, subjects should be frontlighted, and the camera can not look directly at very bright light sources without damage to itself. Theft preven-

tion should also be part of over-all system plans.

Single Camera Systems. The simplest system consists of one camera, wall or ceiling mounted, connected to one monitor. The least expensive setup of this kind involves using an existing TV receiver as the monitor. Most cameras have what is called an RF output signal as well as a pure video signal. The RF signal is adjustable for a range of channels usually running from Channel 2 through Channel 6. The coaxial cable from the camera is terminated with an impedence matching transformer which in turn is connected to the VHF antenna terminals of the TV set. The picture being transmitted by the camera will appear on the TV set when it is turned to the proper channel. This system can be had for $300 or less, if one already has a TV to use as the RF monitor. If it is not desirable or practical to use a home set in this manner, a separate video *video* monitor should be purchased. The video monitor makes use of the video output of the camera, and it generally will have a sharper picture than the RF receiver. Complete systems that include a camera, monitor, cable, and in some cases even an intercom cost $400 and up. Caution should be exercised when considering the lowest priced systems. Picture quality and system reliability sometimes leave a lot to be desired. All in all such simple systems should greatly increase the ease and amount of observation the raptors receive.

Multiple Camera Systems. For more complete coverage of a breeding enclosure, or the observation of more than one enclosure, more than one camera may be needed. Each camera may have its own monitor, or a multiple-input-single-output switcher may be used to display the desired camera output on a single monitor. More details on switchers will be found in the section on camera accessories. The use of more than one camera per enclosure would likely involve using one camera with a wide angle lens for observation of general activity, and a second camera with a telephoto lens for detailed observation of the nesting site.

Camera Accessories. There are many camera accessories available that will greatly extend the usefulness of any video camera.

Lenses. Lenses come in a variety of forms. Wide angle lenses give a large field of view with little detail. Telephoto lenses give a close, detailed view of a small area. A zoom lens allows the user to adjust over the whole range, from wide angle to telephoto. Fixed focal length lenses usually cost less than $100. Manual zoom lenses start around $200, and remote controlled zoom lenses start at about $900. Special lenses for use in very low light levels run between $200 and $350. Lens choice is important since it plays a large part in what the observer will see.

Scanners. Scanners are devices that allow the camera to pan back and forth over the scene. They may be either automatic or remotely controlled to allow for stopping the camera on a particular part of the scene. Thus, a lens that is more telephoto than wide angle in nature may be used without losing the ability to see the whole scene. Automatic scanners run $125, and remote controlled

ones around $250.

Pan and tilt devices. Pan and tilt devices permit both horizontal and vertical positioning of the camera from a remote location. They cost between $700 and $1000. Coupled with a remote controlled zoom lens, this is the ultimate in control the researcher may have in choosing the scene to be observed.

Environmental enclosures. Temperature extremes or exposure to the elements requires placing the camera in an environmental enclosure, which costs around $200 with a heater and blower.

Switchers. Switchers for routing video signals to monitors or video tape recorders may be simple, inexpensive ($50 or less) push button devices, or sophisticated sequential electronic switchers costing $300 or more. The simple switcher will suffice in many cases, but the sequential switcher offers several special advantages. With the simple switcher, the camera output desired may be punched up for display on the monitor at will. With the sequential switcher, the monitor will sequentially display however many cameras are connected to it. The time between switching is adjustable, and if any one scene is desired for extensive observation, the sequencing can be stopped at that input. See the section on video tape recorders to see how this switcher may have further uses.

Video tape recorders. For cost reasons, compatibility, and availability, only video tape recorders (VTR) using half inch video tape will be considered. They are capable of making high quality recordings and are usually quite reliable. SONY, Panasonic, Javelin, and Hitachi are quality brands of both VTRs and cameras. The simplest VTRs record and play back a video signal and usually have a stop action feature. The next step up adds electronic editing and slow motion playback capability. The simple VTR costs between $695 and $800, while the more sophisticated models run $1000 to $1200. The maximum record time for these units is one hour with a conventional 2400 foot, seven inch roll of video tape. Special thin tapes may extend this time by 25%, but give decreased service life. A standard one hour roll lists for $40, but a dealer with any kind of volume usually makes them available for about $25. The tape may be erased, recorded on, or played 500 times or more before becoming unusable. The one hour time limit may be avoided by using a special time-lapse VTR. These record at a slower speed than a standard VTR, and therefore a one hour tape may be stretched to a seven, 12 or more hour tape. The author recommends that no greater than a 7:1 or 12:1 reduction be used if any degree of clarity is to be maintained for the picture. Besides being able to record extended periods of time, the time-lapse VTR can greatly aid analysis of the material recorded. The recorder is played back at standard speed until some unusual activity flashes by. Then it may be slowed down for detailed observation. Thus, a whole day's activity may be recorded and reviewed in less than two hours time! Nothing is missed and researchers' time is saved for other duties. If the output of a sequential switcher is connected to the time-lapse VTR, a sampling of a whole day's activity for many cameras can be obtained. Time-lapse recorders cost between $1700 and $3000. The author personally feels the Javelin X-400 at $2000 offers the most in features and performance, especially slow playback. Its only drawback is that when service is required, only a Javelin dealer is likely

to have the tools to do the job. On all the VTRs discussed an audio input is available. With the use of microphones in the breeding quarters as well as cameras, nothing is missed.

Summary. From this discussion of closed circuit television, it can be seen that anything from a shoestring budget to a federal grant is needed for financing of a system, depending on the degree of sophistication required by the researcher. Closed circuit television can give the researcher the tools needed to do an in-depth analysis of the subject's behavior. From this should come better understanding of the complex processes involved in getting raptors to breed in captivity. Following this should be more successes and easier duplication of them.

[The author is in a position to offer new equipment at a 10-15% discount (plus shipping) to serious researchers. Also, the author will offer limited (timewise, not ability) consulting services free to those seriously interested in the design and purchase of closed circuit television systems.]

RAPTOR RESEARCH

Volume 6 Supplement Part D 1972

SPECIAL CONFERENCE ON CAPTIVITY BREEDING OF RAPTORS—A REPORT

Sponsored by Raptor Research Foundation, Inc.
Held at Sioux Falls, South Dakota, U.S.A., November 22-23, 1971

Part D. Rearing, Parental, Foster, and Hand (Panel 9)

edited by
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Panel Members: James Enderson, Chairman, Robert Berry, Richard Olendorff, and John Snelling.

Although the pre-hatching period in the artificial rearing of raptoral birds is usually attended by a good deal of apprehension on the part of the person in charge, the rearing of hatched young to adulthood can be accomplished quite easily. For perspective, this panel outlined some of the characteristics of the rearing of young by wild adult Peregrines and then explored the various techniques and possible pitfalls involved in captive rearing.

Stan Temple presented time-lapse motion picture data obtained from wild nesting Peregrines on the Yukon River in the summer of 1970. A more complete report on this work is in press (*Living Bird*—Enderson, Temple, and Swartz). Throughout the first week after hatching young Peregrines were brooded by the adult over 95% of the time where ambient temperatures averaged 57 F.

After the first week, there was a rapid drop in the attentiveness of the brooding adults. Brooding occurred 10% of the time after the age of three weeks. Correlations in the amount of brooding of young by the adults appeared to occur with changes in weather conditions. As one would expect, brooding was more frequent during rainy periods, and when temperatures were below the average for the period. The implications of these data are that young Peregrines will require the artificial application of heat almost constantly until they are five to seven days old, and thereafter can tolerate room temperatures and lower.

The time-lapse films showed that young Peregrines were fed within four hours after hatching, and that the average rate of feeding by adults approximated two feedings per young per day in the first five days of life, and that this rate increased to nearly three feedings per day per young at least until the young were 25 days old. The interval between feedings was as high as seven hours within the first few days of life, and then decreased to about four to five hours thereafter. On the average, each feeding session by the adult lasted only about ten minutes. There were no instances where young Peregrines up to the age of four weeks were observed feeding themselves. Unfinished prey items were never left on the nest ledge by the adults. The time-lapse films also showed that there was a very marked decrease in the participation of the male on the nest ledge after hatching. The female did virtually all of the feeding and brooding. Two day old young Peregrines were very sensitive to over-heating in direct sunlight and actively sought shade at that age.

In regard to foster rearing in captivity, Bob Berry commented on numerous recorded instances of the adoption of the young raptors by foster parents of their own or other species. It also appears that lone adults will adopt young of various ages. Generally, these adoptions have followed an unsuccessful attempt by a broody pair or lone adult to produce young of their own in captivity. There have been unsuccessful attempts to cause adoption after the foster parents have stopped "brooding." There have also been the cases of a captive Gyrfalcon and a captive Peregrine Falcon, that have adopted and successfully raised young without entering into a breeding cycle at all. Successful foster rearing has occurred in accipiters, buteos and falcons.

Richard Graham described an instance in 1971 in which a pair of Prairie Falcons, after the incubation of infertile eggs for four weeks, readily accepted a pair of very young Prairie Falcons and reared them. On the other hand, a pair of Peregrine Falcons, that had not incubated eggs, killed a Prairie Falcon chick as soon as it was placed with them. Fran Hamerstrom related an account of a Golden Eagle that accepted a one-day-old chicken, and one of a Red-tail, which after accepting an adopted Red-tail chick, also adopted a white mouse.

According to Bob Berry, there are three major pitfalls in allowing captive adult raptors to rear young. The first is that after a diet of day-old chickens, cannibalism of the young raptor by the adults can occur. This circumstance was seen in Henry Kendall's Prairie Falcons, where the adults attempted to eat the young. Adult Sparrow Hawks cannibalized their young in a project operated by Tom Cade. Fran Hamerstrom also cautioned against feeding captive adults food such as day-old chickens that are similar to birds they will later be expected to adopt. A second problem, experienced by Berry, was the failure of a Goshawk to brood her nine-day-old young. A third problem, experienced by Heinz Meng in 1971, was the failure of the adults to feed the young, even though they appeared to be doing so. Don Hunter cited his own experience in which an adult Goshawk adopted a very small chicken even though it had been fed day-old chickens prior to that time. It was pointed out that the peeping of young raptors, or for that matter, young chickens, may inhibit the adult from killing them. Hunter also cited an instance where a pair of Red-tails incubated and

raised a young goose until it was large. Phil Shultz said that his pair of Prairie Falcons immediately brooded orphan Prairie Falcon chicks, but did not feed them for two or three days, and they had to be fed by hand until that time.

On the subjects of artificial brooding and hand-feeding of young raptoral birds, John Snelling spoke of hand-rearing 19 artificially hatched Kestrels on day-old chickens, pigeons, mice, and sparrows. The food items were plucked or skinned, and then the bones finely chopped with scissors. The temperature of the still-air brooder was 95 F for the first week after hatching, 90 F up to three weeks, and 72 F thereafter. He also said that he had had a good deal of trouble rearing eagle chicks in Africa, where he had no means of accurately controlling brooding temperature.

Richard Olendorff reported on a project involving the hand-rearing of Red-tailed Hawks, Ferruginous Hawks and Swainson's Hawks. Immediately after hatching the young buteos were left in the incubators at 99 F, and showed no distress. After 12 hours, heat was applied by means of incandescent lamps and the proper temperature was obtained by trial and error. If the birds were too cold, they shivered, and if too hot, they panted. The appropriate brooding temperature from the first to the third day appeared to be about 88 F and between the fifth and the sixth day, it appeared to be about 81 F and about the eighth day, 77 F. Thereafter, the application of artificial heat was unnecessary. The birds were brooded separately and it was pointed out that if three or four had been brooded together, perhaps less heat would have been necessary. The young buteos were fed every four hours, beginning within a few hours after hatching.

James Enderson mentioned that the down on artificially brooded young falcons does not appear to fluff readily after hatching and that stroking with a feather can raise the down and reduce the heat loss. Brooding temperatures on several freshly hatched falcon chicks he reared were held between 90 and 95 F. Chicks that are too hot tend to pant and stretch; those that are too cool tend to chirp, and pull their head under their abdomen. After the fourth day, the brooding temperature was lowered to 87 or 88 F for the next four days. Bob Berry also reported that young Goshawks and Peregrines show stress at temperatures below 88 or over 92 F in the first week of life. In regard to temperature, Heinz Meng mentioned that he placed a newly hatched Peregrine chick in a long box with a heat source, a light bulb, at one end, so that the bird could regulate its own temperature by moving toward or away from the bulb. After about the first week, the chicks can tolerate room temperatures. A still-air styrofoam brooder was used by Enderson, and a thermometer kept at the level of the upper surface of the chick at all times.

Young falcon chicks kept on a relatively smooth surface such as paper towel seem unable to keep their legs beneath them or to raise their heads readily, while those kept on coarse gravel do not experience that trouble. Bob Berry mentioned that he had experienced the same problem in Peregrines and Goshawks, and solved it by placing the birds on a soft towel in a bowl. Fran Hamerstrom mentioned that she has provided emergency heating for the young by placing it inside of her shirt! She noted that chicks covered with a piece of

cloth are usually resting and when the cloth is removed they quickly raise their head in anticipation of being fed. She has used an unorthodox brooding technique in the cases of very young harriers, horned owls and other species. The young are carried under clothing just above the belt, supplying warmth, contact and motion to the chick. When older, the chick is placed in a strawberry box on a cloth pushed into the box. The chick is then covered with a cloth to provide weight because "when a brooding raptor rises to feed its chick, the youngster is exposed to light and lack of tactile pressure. Light and the release from pressure are the dinner bell. When I take a chick out from inside my shirt, or remove the sock from the basket, I am giving the same signal, and the heavy-headed chick has not wasted its precious time and energy in vain waving its head about nor struggling for footing before this time." According to Berry, artificially brooded chicks do not readily submit to being brooded by adult birds, although they eventually learn the source of the heat.

Richard Fyfe noted that wild Prairie Falcon chicks are negatively phototrophic in that they turn away from the light and huddle towards the rear of the ledge.

RAPTOR RESEARCH

Volume 6 Supplement Part E 1972

SPECIAL CONFERENCE ON CAPTIVITY BREEDING OF RAPTORS—A REPORT

Sponsored by Raptor Research Foundation, Inc.
Held at Sioux Falls, South Dakota, U.S.A., November 22-23, 1971

Part E. Housing and General Management (Panel 2)

edited by
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Panel Members: Richard Fyfe, Chairman, James Enderson, Heinz Meng, James Weaver.

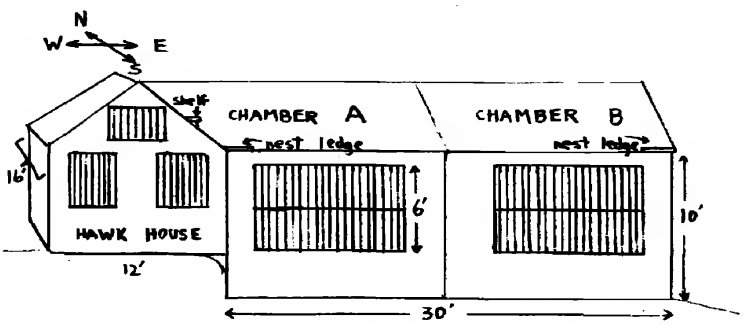
HUNTER. I'll introduce the next panel which is Housing and General Management and Richard Fyfe is chairman of this panel.

FYFE. Thank you, Don. Since several of our panel members won't be able to make it, I've asked Dr. James Enderson and Mr. Jim Weaver to fill in and I'm very pleased that these people have accepted. Of the original panel Dr. Meng and myself are here and we thought that we would begin by first generally outlining our facilities and what we feel are the strengths and weaknesses of these. Then go through the various aspects of raptor facilities point by point and hopefully open this to some discussion from the floor. The panel will be Dr. Meng, Jim Weaver, Jim Enderson and myself, and I think if you're ready, Heinz, we'll go right on into the description of your facilities.

MENG. My work with raptor breeding and the development of my breeding facilities started many years ago. In 1946 I caught a passage female Red-tailed Hawk that I have kept for the past 26 years. She has been kept on an outside perch throughout the year next to an enclosure into which she can fly when it is stormy. She has laid two or three eggs each spring since she was four years old. Usually I substitute these for glass eggs and allow her to incubate them one year. She even incubated the eggs in snow following a late storm in April. She

is tethered throughout the year and builds her nest on the ground next to the perch. Several times we have provided her with foster young and she has fed and cared for these birds conscientiously. One year I removed her first clutch of three eggs and three weeks later she had recycled and laid two more eggs. Many hawks when they become older become sort of like brood hens and will raise almost anything that is put under them. She has even raised a chicken which she hatched and raised to about three weeks of age. Whenever the chick got cold it would go under the red-tail just as if it were the mother hen. Unfortunately one night there was a thunder storm and the chick walked away and died of exposure.

My breeding chamber initially began with a small white-painted hawk house built in 1953. In 1963 I built an addition to the hawk house specifically designed as a breeding chamber for a pair of passage tundra Peregrines. The breeding chamber is located in our back yard and is very secluded. It is surrounded by many shade trees so that it is quite cool in the summer, also there is a swampy woods in back. As illustrated the breeding chamber was attached to the original hawk house.



At first the 1964 pair of passage Peregrines (*Falco peregrinus tundrius*) had the entire chamber to themselves, but in 1969 this chamber was partitioned to make two separate chambers. The partition was made out of 2x4 lumber and covered with burlap on each side. Entrance is through the hawk house into chamber A; in order to get to chamber B one must go through chamber A. Therefore, by going through the hawk house there is always a closed door so that the birds cannot possibly escape. Window areas, without glass, are provided in the north and south walls of the chambers. The windows are 6'x10' and are provided with 3/8" vertical hollow aluminum rods placed 2½" apart center to center. The window areas facing north are 4'x10'. On the outside the aluminum bars are covered with 2"x4" mesh welded wire coated with vinyl to prevent escape should one of the falcons be able to push between the bars. At the bottom on the window areas on the south there is a 3' wide shelf with a lip 2" high. This whole area is filled with sand. At the end of each shelf there is a large bath pan. At 3' above the bottom shelf there is another shelf 3' wide covered with synthetic rug and astroturf material. The north window areas are smaller but

have no shelves. The upper half of each area is covered with burlap to provide some protection from the north wind but the open lower half allows some wind to circulate through. The floor is of cement. Perches and shelves are arranged so that the birds cannot defecate on them from above. There are only three rafters in each chamber and these are covered with rug or astroturf. The birds usually use these to roost on since they are the highest perches available. The interior of the breeding chamber is unpainted, and the walls are of homosote board, a pressed fiber material. Although there are lights in each chamber they were not used during the 1971 season. In chamber A, which houses the Peale's Peregrines, the nest ledge runs north and south along the eaves of the original hawk house. The ledge is two feet wide and has a lip of rug covered 2x3 inch wood, sand about 2 inches deep fills the entire ledge (dimensions 2x15 feet). The part of the hawk house roof that is covered by the breeding chamber forms a darker area above the nest ledge. Half way up this sloping roof is a horizontal shelf about one foot square; often both birds sit on this ledge together. A one-way mirror has been installed in the peak to facilitate observations of the pair. The perches are all padded. In addition to the ledges there are a couple of stone ledges (cement blocks) where the birds can sit if they so desire.

Successful Peregrine Breeding in Captivity. The Peale's Peregrines used in the successful breeding attempt were taken from the Queen Charlotte Islands in British Columbia in 1967. They were taken almost as branchers and each bird was from a different eyrie. The birds were initially handled for about a month and were then put in a small holding chamber which was about 12 feet x 4 feet x 7 feet high (the south end of the original hawk house), and here they were kept for the next two years. At two years of age, the pair was put into the breeding chamber which was 10 feet x 15 feet x 10 feet high at the eaves (chamber A).

The pair was fed from the outside of the breeding chamber and as early as the fall of 1970, the male became quite aggressive. Their food consisted mostly of fat, healthy, freshly killed homing pigeons. As a precaution against trichomoniasis the heads and crops are removed, also the feet. The pigeons are then torn into three pieces by pulling the wings apart, which tears off breast from the breast bone, and then removing the back and legs from the breast piece which is still attached. Viscera are not removed. The food is then fed on the upper window shelf from the outside. Both birds come to the ledge and take the food from my hand. Also day old chicks and an occasional rabbit have been fed to this pair of birds. No drugs or vitamins were used, although wheat germ oil was mixed with yolk and put on the meat for about a week during the end of February, but they don't like the taste. At about the time of egg laying, the male became even more aggressive towards me and would actually try to get me through the bars. Several times I would run along the side of the hawk house in sort of a crouching position and he would be very vocal, run along the window shelf, and try to attack me. I feel that this stimulated him sexually and perhaps had something to do with his being fertile. Often I could look in from the outside and see the falcons glaring down at me with their wings poised for a flying

attack.

The birds were both very vocal and four eggs were laid at two day intervals starting March 4, 1971. After eight days of incubation the eggs were candled and found to be infertile. These eggs were then removed and 13 days later the falcon had recycled and laid four more eggs. For each clutch incubation started with the third egg and the female did most of the incubation at the beginning, but as time went on the male did more and more. Copulation was not observed and it is felt that it probably occurred on or above the nest ledge. Incubation of the second clutch was not interrupted and three eggs hatched on May 8th and one young on May 10th. During the incubation period the male took food to the nest ledge and gave it to the female. It was noticed that the female went to the nest site and started plucking and eating at the time the young were peeping. On May 10th, two days after I heard the first peeping I finally climbed to the nest ledge. I hadn't disturbed the falcons since the laying of the third egg of the second clutch. When I climbed to the ledge (1:00 PM) I found two dead young, one almost dead, and another just hatching. I brought the young into the house, but the one which was almost dead died shortly after, and the one that was hatching was out of the egg at 2:00 PM and immediately ate three small pieces of fresh pigeon breast meat. For the next ten days he was fed mostly skinned eviscerated day old chicks. These were cut up and fed with round tipped forceps; all of the bone and cartilage was fed along with the meat. A 40 watt bulb was used for heat and was so regulated that the temperature stayed at about 35 C (95 F). The bird was able to move away from the light if it felt too warm.

It appears as though the female fed herself at the nest ledge but did not feed the eyasses although she brooded them well. I did not use any supplementary vitamins and on occasion I did give him little slivers of fresh pigeon breast. However the main diet was day old chicks. During his 14th day of life he consumed eleven chicks. The skin and feathers were removed so that there would be no pellet forming material. Every two hours I simply fed him a full crop and I did not have to wait for pellet regurgitation.

In summary, the results of the 1971 breeding attempt are as follows:

First clutch—4 infertile eggs laid, removed on eighth day.

Second clutch—4 eggs laid, all fertile, all hatched—three of the four young died apparently due to inexperience of female, the fourth young was successfully hand-reared with the result that one Peale's tiercel was produced. He is in perfect health and plumage, with no hunger streaks and weighs 24 ounces.

THOMAS. At what age was the eyas removed from the parents?

MENG. He was removed before he came out of the egg, just at hatching. Actually the three eggs began hatching on May 8th. I heard a lot of peeping and I provided food on the window ledge. The male came and brought the food up to the female and I could see her plucking it. I could see the back of her tail and the young ones were peeping so I thought everything was going fine and I pro-

vided them with a pigeon twice a day torn into three sections. On the following morning I went out again and as soon as she got off the young ones started peeping and the same thing happened, that is the male brought the food up and she began eating. On the third morning I didn't hear any peeping so I decided that I had better look because I hadn't been up there since the third egg of the second clutch. I didn't want to disturb them and when I went up there again I saw that two young were dead and another was practically dead. The fourth was just coming out of the egg. Apparently the female had gone up there and fed herself but hadn't fed the young ones although she was brooding them. As soon as I saw that I grabbed everything and hand-raised the last young in the kitchen. I put him under a lamp and fed him about every two hours. It was unfortunate that that happened. Several others have had young prairies and the females fed their eyasses all right, but this female apparently fed herself but didn't feed the young. Next spring what I plan to do is take them when she hatches them and put additional eggs under her for about one week, raising the young inside. Then I will re-substitute so she'll be getting a group of young that are a week old already. Maybe she will be mature enough then so that in the future perhaps I won't have to continue in this substituting.

VOICE. What is the floor covering?

MENG. Just cement, but they rarely go down onto the floor unless it is to catch a live chick that may have fallen down from the feeding shelf.

ENDERSON. Do you keep the pair together year round?

MENG. Yes. They have been together for as long as I have had them. When I first got them they were put in the original hawk house in a four foot wide section that I had partitioned off. They were there for three years while the tundra birds had the complete run of the breeding chamber. Since then they have been in chamber A.

VOICE. How much manning have these birds had?

MENG. The first year that I had them, for a period of about a month and a half, perhaps two months I would take them out and put them on block perches and take them in at night, putting them on my elevated shelf perches.

VOICE. What about the diet of the adults prior to egg laying.

MENG. The diet consisted mostly of freshly killed homing pigeons, also day old chicks.

THOMAS. Did you have problems with wind, etc., and disturbance?

MENG. Not too much. If you think back I mentioned that on the northern

exposure, the north windows are 4x10 feet with the top two feet covered by burlap woven between the bars. So there is just a 10x2 foot wide strip that is open on the north exposure, with the result that there is no difficulty and they are out of the wind.

THOMAS. Did you ever, like Jim Enderson has done, try using barrels to try and stimulate more of an eyrie cave type situation? I have seen a prairie project where there were ledges and nothing was happening, but the day they put one barrel in the prairies were in there clucking and just going crazy. They seem to like the protective nature of such a situation.

MENG. I haven't used barrels, but as I mentioned the nest site was back in the corner in the most hidden area of the breeding chamber.

WEAVER. The new facility at Cornell University, Ithaca, New York is a steel sheeted building 227 feet long and 47 feet wide. It is divided inside to house 38 pairs of birds in 38 separate chambers. Thirty-six of the chambers are approximately 10x20x17 feet at the apex of the roof floping to 14 feet at the eaves. The entire area is surrounded by a six foot Cyclone fence with a barbed-wire top. The outside openings of the pens are screened first by one-half inch steel conduit bars. Six inches beyond the bars the outside open area is covered with half inch hardware cloth and the bottom two feet are covered with fiberglass light panel. The fiberglass is primarily to take up the extra space left from the conduit as the conduit lengths are only 10 feet. However it turns out that it is a good idea to keep blowing snow off the bottom of the cages. Inside, the walls of the pens are paneled in plywood. The roof has at least one sheet of light panels that are white. Each room has two or three wall perches, most of which are covered with cocoa matting. We were using hay bales, but with the expense combined with the problem of molding, we have decided to replace these with cocoa mats, which seem to closely resemble the texture of perches used in the wild (that is tundra heather, dwarf birches and that sort of thing). Each room has at least two ledges that can be used for nesting; these are filled with gravel. The edges of all the perches are padded with Tartan Turf, similar to Astro Turf. Each room is vented at the top with half inch hardware cloth behind the wooden bars, situated above the lights. Because the temperature immediately under the steel roof can exceed 100 degrees in the summer we have installed roof ventilators. We feel that with three big ventilator fans the length of the building, we should be able to draw enough air from the front to cool it considerably. Each room has the facility for eight 150w flood lights for artificial lighting, and a pane of one-way glass for observation. There is also a double decked observation hall that runs the length of the center of the building. Of course it is also heated to an extent in the winter so that it will not freeze, and it affords good opportunity for observation. The floors are covered with gravel and we furnish a little bit of straw underneath the perches to facilitate cleaning. Our plans are simply to go in once or twice a year to take the straw out and work the gravel over with a weak solution of formalin as is done in the poultry industry. We

have been feeding a number of birds on the fist in an effort to try to keep them as tame as possible. We don't know whether it is going to be really valuable or not, but in most cases it would seem that the smaller the disturbance caused by entering the pen, the better your chances are going to be. I think in some of them we will completely isolate the bird during the breeding season. That is, we will just put food in through the observation port or something of that sort.

ENDERSON. I am describing the new facility that I built in the past summer at Colorado Springs, which may be of interest to many of you, because the cost involved is considerably less than the larger facilities such as at Cornell. This building consists of five parallel rooms, each six feet wide. Each room is 18 feet long except that the nest ledge on one end adds three more feet to that dimension. There is an enclosed alley-way adjoining one end of all five rooms, with doors opening into the breeding chambers. The outside dimensions are 30x24 feet; the cost is around $1,300 for materials.

Each room is equipped in the same manner. The interior walls are painted white, the floor is dirt. The perches are straw bales, except for the lip of the nest ledge which is covered with nylon carpet. The nest ledge is covered with two inches of coarse sand and small pebbles. In Colorado bales of straw tend not to mold, so they are suitable for use as perches. A lower perch projecting from the wall at eye level, enabling the birds to fly from the floor to the higher perches in two steps is provided.

The opening in the roof is 3x12 feet and is covered with 2x4 inch welded wire.

Behavior of Captive Pairs. The four pairs of Prairie Falcons vary in their adjustment to each other. Members of compatible pairs seem to notice each other; in fact, at times they step on each other's wings and tails without paying much attention to it. I have never noticed any kind of antagonism among two pairs. Another pair, including birds which are about eight years old, appear to me to be poorly adjusted to each other. They are very tense in captivity and easily frightened, even though the female has laid eggs and the male copulated with another female in captivity in 1967. They are tried and proven in that sense, but they seem not to be compatible. In another pair of Peregrines, the female perhaps is dominant over the tiercel and forces him to move. Also with the birds which seem compatible and adjusted in the nesting situation, a play-type of behavior has been observed where the birds appear to play with the wings of three week old chicks which had been a steady in the diet of these birds.

FYFE. In contrast to the previous discussions of breeding projects and breeding facilities, we have been working with a very different situation in that we have been forced to use a large number of different breeding chambers, each with different dimensions, exposures and natural lighting. Due to such factors as availability of buildings, incompatibility of birds or apparent non-adjustment of birds to a given situation, we have had to improvise a great deal and in so doing have experimented with a variety of different situations for perches, ledges and lighting. We have moved our birds around to different rooms and have de-

liberately altered the amount of natural lighting to which they would be exposed. We have experimented with a variety of perches and perch locations and have even painted the insides of the chambers white in order to increase light intensity.

Room Size. Our breeding chambers have ranged in size from the smallest rooms approximately 12x12x6 feet high to rooms as large as 30x20x18 feet high. In general our observations of the larger falcons suggest that the smaller rooms contribute to a high degree to the anxiety of the birds. We have had Peregrines, Prairies and Gyrs in small rooms and it appeared that their inability to avoid the nearness of any intrusion created a great deal of anxiety. In such a situation these birds were observed to fly directly into walls, the bars of windows or into the weld wire. These large birds also appeared to have a tendency to fly just below the ceilings of these rooms with the result that most were constantly tipping their wings as they flew from one perch to another. In contrast, the smaller birds, kestrels and Merlins, did not seem to have the same degree of difficulties in these small rooms, although they also exhibited a degree of anxiety and would fly into the walls or the wires covering the windows, when we entered the pen, otherwise they seemed well adjusted and did not have the same tendency to tip their wings on the ceiling as they flew. One pair of Prairie Falcons kept in a small room of this type did however lay five infertile eggs in a barrel-type nest ledge in 1971. Initially this pair exhibited the same sort of anxiety which we attempted to minimize by staying away from the pen for the most part; however, once egg laying began, aggressive behavior became more dominant, and it was extremely dangerous to enter this small room with this particular pair of birds. In contrast, we had our pairs of adult Peregrine and Prairie Falcons in rooms which were much larger by dimension, roughly 27x17 feet and about seven feet high. Although these birds were not as easily disturbed by our presence there still was a tendency to fly from one end of the room to the other and into the wire screen covering the window. There was not quite the same tendency to fly immediately next to the ceiling and a minimum of feather damage was recorded. In 1970 and 1971 we did not have any birds attempting to lay in these pens although we did provide them with both barrel and open ledges and we believe the primary reasons for the lack of breeding was the fact that we had immature birds included in each pair in these rooms. (This has been borne out since in 1972 we had two pairs lay in these pens.) The next largest chamber that we used was the chamber in which we had successful breeding. This was a room 27 feet long by 12 feet at the apex sloping to about seven feet. The most obvious behavior of the pair in this room was simply that they had a tendency to fly from one end to the other; however, the mere provision of higher perches seemed to result in a major adjustment. It was particularly noticeable that within a couple of days of the placement of the Prairie Falcons into the pen, they would sit above us with relative indifference, in sharp contrast to the frantic flying which had been so prevalent with this pair in the previous pen which had a low ceiling. This chamber was situated on the north side of a barn and consequently received only a small amount of sunlight. Initially, the east

end of the room was covered with one inch weld wire but was later covered with fylon when we observed the birds altering their behavior with the slightest movement or activity observed outside of the building. In order to increase light intensity, the roof of this building had also been opened into long sections which were covered with fylon and the inside of the room had been painted white with the exception of the small area immediately behind the nest ledge. The west end of the building had a large window, 4x6 feet. This window afforded some opportunity for these birds to sit in the sun in the late afternoon or evening. Two small windows on the north side were only about five feet in height and were seldom used by the birds.

The largest pen was the loft of a barn which had been renovated and was felt to be the best of our breeding chambers for the larger falcons. The rough dimensions were 27x28x18 feet high; i.e., it was large enough to provide an opportunity for these larger birds to fly around inside. The birds in this pen did fly a great deal, receiving a considerable amount of exercise and were in excellent condition, judging by their case in making the floor or food ledge to the higher perches. This room was open for the full length on the south side and openings were covered, also part of the east end of the building and a small portion on the roof at the southeast peak of the roof. All open areas were covered with one inch weld wire. Perches were installed specifically so that the birds could sit in these open areas to receive a maximum amount of sunlight. This room was also judged to be the most suitable because of the obvious adjustment of the birds to the breeding chamber. We believe that the height provided the necessary security for the birds and the size of the room, perches and available nest sites seemed to meet the basic requirements. Unfortunately, the pair which were in this room for two years laid infertile eggs both years, as discussed later in the section on behavior.

Lighting and Enclosure Coverings. All of the breeding chambers in the project have been lighted through natural lighting conditions, primarily because the natural lighting at our latitude provides the natural photoperiod for the Prairie Falcon, Peale's and anatum Peregrines. A serious attempt was made in all of our buildings to create as large an opening or alternately flight pens on the south and west sides of the buildings. These were generally in the form of open windows covered with either fylon or weld wire. We also used fylon extensively to cover open areas of the roof or to screen the larger windows so that the birds would not see activities which might disturb them. We have found that the clear fylon is a very suitable material which allows a maximum amount of light, although it does screen ultraviolet we are told. Because of the problem of birds flying into the wire of windows or other openings, we have tried to minimize this by placing perches adjacent to the wire screening. We found that the birds used these extensively and very often this has solved the problem of an individual bird flying into the wire. With Merlins and with Prairie Falcons that were prone to fly into wire, we have used snow fencing on the outside of the wire which creates a visible barrier. The birds tend either to perch in front of the snow fencing, or if they do strike the wire, they strike feet first. This has greatly decreased the number of times the birds have flown directly into the fence and

has virtually eliminated the problem of cut ceres and broken or frayed feather ends.

Ledges. We have used three different types of nest sites. For the larger falcons we have used open ledges with a narrow lip which were filled with turf, gravel or sand or a combination of each. Most recently we have been using a fine gravel and have found this eminently suitable. We have also barrel ledges with a similar substrate; however, in 1971 where we had both barrel ledges and an open ledge in the pens, both the Peregrines and Prairie Falcons chose the open nest ledges. (In 1972 all three pairs of adult birds chose barrel ledges.) The Peale's Peregrines were provided two open nest ledges and one barrel nest ledge the same height in 1971. The second nest ledge is actually lower than the barrel ledge. In the two nesting attempts this pair chose the open ledges. We have also provided barrel ledges in rooms that were without other provision and in the case of one pair of Prairie Falcons they laid in the barrel ledge provided. The third nest site provided was simply an old Magpie nest for our year old Merlins and although we did observe some activity in association with the nests, the birds did not lay. Since this is the normal nest selection in the wild, we felt that this was the logical choice for these birds in captivity; however, because of the difficulty in moving these nests, in the future we will construct our own using twigs and wire frames.

Perches. As indicated, we have tried several types of perches and locations. In general, these have ranged from normal flat wooden perches of 2x4 or 2x6 to round perches usually in the form of natural tree branches. We have tried swinging perches which are simply tree branches tied at each end and suspended from the ceiling and also straw bales, both suspended on walls and left on the ground. Our flat perches have been covered using such materials as cocoa matting and sand or gravel.

By preference, we have now settled pretty well on straw bales, and tree branches for perches. Straw bales are very excellent in our area because they remain dry, can be changed readily, and we believe, they provide some relief to the birds' feet. Tree branches are also suitable, easily obtained and because of the round shape, provide a perch where the bird is not sitting on the ball of the foot, which again we believe is of some assistance in the elimination or prevention of foot problems. We have also used swinging tree branch perches particularly for larger birds such as the Gyrfalcons, and although these are suitable, they have their limitations and are difficult to suspend properly.

Any discussion of perches inevitably comes back to the question of foot problems and generally I can only say we have had very few foot problems. Curiously the majority of these problems with us have been with Peregrines and not with Gyrfalcons or Merlins which have so traditionally been prone to foot problems. For the most part, we have been able to solve foot swellings by provision of alternate perches although in cases where a corn was involved, we have had to go to minor surgery.

It is our observation that the choice of location of perches is very important and that three basic considerations should be met; i.e., (a) they should provide security for the birds (height with large falcons) (b) there should be provision

for the female to perch near the nest ledge prior to egg laying and (c) perches should be situated so that any attempt at mating would not be thwarted by the location (e.g. closeness of the perch to the ceiling). We have attempted to provide two or three perches near each nest ledge, one adjacent to the ledge and two to one side or the other and also a perch across the mouth of the nesting ledge itself. We have found that the birds appear to prefer to eat on straw bales or a flat surface of this nature, and will carry their food to straw bales or a flat ledge for plucking and eating. High perches at or near windows are designed to provide an element of security and at the same time allow the birds to spend a good deal of time in the sun.

Blind. If you wish to know what is happening and unless you have very tame birds, the provision of a blind or a suitable viewing area is absolutely essential in establishing new breeding pairs of birds. Although the benefits are described in some detail in the section on behavior, it is worth indication that a blind should have the following features. First it should provide you with the opportunity to approach and observe the birds without being seen by them so that they will not be disturbed nor aware of your presence. We have also found that blinds provide suitable opportunity for recording and photography; however, if this is going to be done, the holes and photoports should be provided well in advance so that the birds will not be disturbed when they are used. Blinds should be large and comfortable enough to provide an opportunity to sit and observe for a considerable period of time without discomfort. We have found one-way mirrors allow optimum viewing provided they are not situated so that the bird is not looking at itself in the mirror. The mirrors should be removable so that they can be kept clean and should be large enough to provide adequate viewing and possibly photography if you so desire. The inside of the blind should be dark as you need a two to one differential in light between the inside and the outside of the blind so that the mirrors function properly. And finally, you should not smoke or, that is, have a lighted cigarette or any bright object such as a match, lighter, flashlight or anything that would reflect light immediately behind the mirrors as this is readily observable and will upset the birds. If you are in a cool climate, the blind should also be provided with some ventilation and possibly a fan so that in the early spring the mirrors do not become covered with condensation. There has been some question as to disturbance due to the blind and I suggest that the birds will adjust readily to sound in most instances; therefore, the blind should be set up in such a way that it can be approached. However, once in use, a little bit of preliminary work, perhaps visiting the blind and moving around for a few minutes a day until the birds gradually get adjusted to it, the use of a radio in the blind turned on very quietly, or something of this type will help to adjust the birds to sound from the blind and they will soon become accustomed to this. One additional suggestion is simply that the blind be situated in such a way that you can look directly into the nest ledges and can therefore be in a position to determine whether the birds are laying or not. Your blinds should also allow you to keep the birds under observation in all areas of the pen so that it is possible to observe the various behavior patterns which might occur in one area or the other.

Floor Covering. The floor covering in all of our pens has been wheat straw. Although straw and hay are apparently considered taboo in some areas, we very much prefer wheat straw as it is clean, relatively dust free and since we are living in a very dry area, it is very easy to keep clean. We do not have problems with moldy material and straw is very suitable since it absorbs the droppings from the birds, is readily cleaned and is very inexpensive.

Perhaps we can now go into the questions. You will have noticed that we have described different types of housing and in checking the literature, it appears that most of the facilities were actually enclosed buildings or large outdoor cage type aviaries or a combination of the two.

SWARTZ. I might comment a little bit just to add to the data on some of these things. I have noticed the same sort of thing with Gyrfalcons which you mentioned with height and found that immediately when the bird had an opportunity of getting away and looking down he was much happier. I have subsequently built some additional quarters with this provision. Your comment on blinds also leads me to remark that for some years now I've had a closed circuit television but since I just use a domestic set, it has to compete with Porky Pig and other such things. So I propagate with R.F. (that qualified as closed circuit). This has been an elegant system and I have boxes in all the quarters that permit rotation of the camera and it's really much cheaper than you probably have thought. Merlins somewhat to my surprise have preferred the kestrel box sort of thing by and large. For somewhat over three years now I have been working with both the progeny of a ground nesting pair and a pair of birds atypical to the Alaskan situation which use an old Magpie nest. I have provided ground situations, ledge situations, ledge situations with overhanging roof and ultimately a giant gigantic chickadee box sort of arrangement made out of old blazo boxes (a wooden gasoline box with a hole cut in it) very much like a kestrel box with a slightly larger opening. As mentioned, it appears that they have preferred the kestrel box sort of thing.

VOICE. What do you mean by swinging perches?

FYFE. These are perches that are tethered from the roof. They are a branch or a trunk of a small tree tethered at either end by a rope so that when the bird lands on the perch it has a tendency to give. We have used these particularly with Gyrfalcons.

VOICE. What's the hypothesis behind the choice of this perch?

FYFE. This perch has been used to permit the birds to land without striking too hard. We have noticed that with Gyrfalcons in particular that they have a tendency to hit very hard when they land on perches and the idea behind the swinging perch is to lessen the shock and thereby prevent injury to the ball of the foot.

GOBEN. I have observations on height that is contrary to what you have in that my pair of Ferruginous Hawks have behaved very differently from the falcons. I had them in an outdoor aviary where they could go indoors and outdoors and they had a considerable height where they could get up and look down on the surrounding yard. That year I did not get anything and I removed the birds and the next spring I put them into a 4x6 cubicle and got fertile eggs.

EBERLY. Did you find any practices or were there any practices that could have influenced the preference of the ledges over the barrels, or did you pretty well arrange things so that there was enough variety?

FYFE. We have tried to arrange the ledges and barrels in such a way that they were all backed up to the wall at relatively the same height. In the largest pen where the Peale's were put up we had two ledges and one barrel. Of the two open ledges one was at the same height as the barrel and one was much lower. In the two nesting attempts these Peregrines used the two open ledges in preference to the barrel. The barrel was used just for stashing food.

STODDART. Are you trying to look for a formula which would be applicable to all raptors or individual species rather than for an individual bird? You seem to be paying a lot of attention to nest boxes or ledges to height and so forth.

FYFE. The thinking behind what we have been doing has been hopefully to find a formula for a given species, in this case for the Peregrine or for Prairie Falcons. The basic idea behind it is to provide security and a situation in which the birds were at ease. I fully realize that birds have different temperaments, but what we have tried to do is to provide them with as many situations as possible and to let them select the situation which they might prefer. We have tried to give them more than we felt was needed in the way of perches and ledges as mentioned, to let the birds select so that we might learn where the preferences may be.

STODDART. Are the birds you are working with from the same source? I would think that if you are trying to find a formula for a species, it would be necessary that all of the young you are working with and the parents would have to be from the same source with the same temperament, and so on. As for example, in the case of Jim Enderson's Prairie Falcons, I think that they would nest in almost anything although this might be a situation which would be very uncomfortable, birds whose history was different from Jim's birds. I personally think everybody seems to be paying too much attention to finding the secret whether it is a nest box, a ledge or height. I don't think that there is a secret and I think the solution lies directly in the birds' securities or insecurities and it will depend on the individual bird species.

FYFE. Basically, I think that I agree with you in that we are trying to make

provisions which will provide for the necessary security of the birds. We cannot tell by looking at a bird what its particular requirements may be; therefore, we have been trying to make as many provisions as possible and are letting the bird more or less select its own preferences.

HUNTER. I think that this poses a very interesting question and one which I had hoped someone would take on. It poses the ecological problem of whether or not an individual will choose the situation in which he grew up, or whether the choice of a site is innate. I think that someone perhaps in the position of Dr. Porter with his experience with kestrels might be able to add something along these lines.

HAMERSTROM. Perhaps in partial answer to the last question, I have found that two horned owls which I have came from different nest sites. One came from a stick nest and the other came from a hole nest. The female selected the stick nest and the male selected the hole nest. I have no owlets.

VOICE. Relative to the use of wire on the pens, have you had problems with the birds flying into the wire?

FYFE. Yes, to some extent we have, particularly with tiercels of all species and definitely with Merlins. When I was in Patuxent last year, I noticed that they had their Merlins in wire pens, I believe, weld wire in construction. However, they had put snow fencing on the outside of the pen and when I inquired they advised me that this kept the birds from flying directly into it. We have tried this with some of our Merlins and with Prairie Falcons and it definitely does help. They still fly into the wire, but they land feet first on it and they do not try to go head first into the wire and damage themselves accordingly. In the same regard, we have not observed any problems with the fylon covered areas.

HUNTER. I have one more question that I would like to ask and I don't know who to direct it to. Has anyone in the group had experience using snow fence on top and what happens when you have a heavy snowfall in such a situation?

SHULTZ. It gets quite heavy. The snow fencing is on wire with 2x4 supports and we haven't had any break-through to date. We have, however, gone out early in the morning and knocked snow off because we felt it does present a potential hazard.

CAMPBELL. I would like to ask Jim Weaver whether or why they use spotlights as opposed to floodlights at Cornell?

WEAVER. They are floodlights.

SHERROD. Also, a question related to the floodlights. Can you tell me what

the intensity would be?

WEAVER. I do not know what the exact intensity would be. We are primarily giving them a good source of light and are not worried about intensity.

LAWSON. Is there any reason why everybody wants to use anything besides artificial light? Why is there this common bond to give them some sort of natural lighting; what is the reason behind it? Someone suggested vitamin D. Do you mean from a supplement?

VOICE. Yes.

VOICE. I question how much value we are going to get from sunlight through this opaque material since it cuts out all the ultraviolet light.

SHULTZ. Several of us have built pens with opaque or plywood walls with screened or snow fence tops. My facility is staggered down a hillside with a 4½ foot difference between the uphill and bottom hillside. It is built with plywood walls so that the bird has no visibility of dogs, children and so forth from the outside and the top is screened with snow fence. We have never had our birds fly into the wire at the top. They have all the sunlight in the world and they can see the blue sky and trees. They seem to be extremely happy in this situation and are comfortable.

SWARTZ. A comment on your point. In contrast, I have not made any effort to use natural light and this is dictated in part by the fact that I've got 50 to 60 degree below winter to get through in Alaska. The more windows I have, the more troubles I have. To date I have not got eggs, but in other respects I feel that I am getting complete response out of incandescent light as the sole source of illumination. To this point I have not considered that there is any super unique magic in any particular wave lengths of light. Although talking with Joe Simonyi shakes my confidence a little. I was clearly within three or four days of laying with my Merlins just a few weeks ago (judging from follicle size) when disaster struck. And that's total incandescent light in a converted coal bin.

STODDART. With regard to artificial light I still think that it might work well with birds taken out of the wild specifically for breeding. That is, if they were kept under artificial light for three or four years. I have tried it on old falconry birds because I thought it would really enhance their environment. In this regard I have done it with two Peregrines and a Prairie; all of these birds were old, the youngest being four years when I put him under artificial light. The birds' condition dropped. The weight didn't drop because I adjusted this, but the birds lost feather bloom so when I put the birds up to mate I didn't consider total artificial light, but this year we are going to have artificial light as supplement. I think for a bird who is three or four or seven years old that has been weathered using falconry methods and is stuck under artificial lights as I have

done three times, that it may be an emotional strain on them. They don't feel right and they don't preen enough and so forth. You know if your bird is losing bloom, when it's baby bloom in the first place, you know something is the matter. Maybe an imprint Peregrine or something that was used to the lights all of the time would compensate for it. But it has adverse effects on a bird that is used to being weathered.

FYFE. I would just like to make one comment in relation to light. We have stayed with natural lighting because we are at the same latitude as the majority of the birds we are dealing with and we felt that in this manner we were in a position to provide them with their natural photoperiod.

HUNT. We should keep in mind that day length is only one cue that birds receive from the environment. There is also the position of the sun, the stars and the moon and I would think that when in doubt, we would be best advised to use natural light.

FYFE. A final note which may be of interest is that as mentioned we are at the same latitude as the wild birds we are dealing with and in our case, both the Peregrines and the Prairies were laying at the same time as the wild birds.

RAPTOR RESEARCH

Volume 6 Supplement Part F 1972

SPECIAL CONFERENCE ON CAPTIVITY BREEDING OF RAPTORS—A REPORT

Sponsored by Raptor Research Foundation, Inc.
Held at Sioux Falls, South Dakota, U.S.A., November 21-23, 1971.

Part F. Artificial Insemination (Panel 7)

edited by
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Panel Members: Robert B. Berry, Chairman, Frances Hamerstrom, Walter Morgan, Stanley A. Temple.

HUNTER. If there are no more questions I think perhaps we can move on to the next thing on our program which is artificial insemination. One of our guests who is here to give us a demonstration has a limited amount of time so we will proceed to that. Now, Bob Berry.

BERRY. I'll be the chairman for this artificial insemination panel discussion. I want to pass out some papers that I have prepared. For those of you who don't get them, you might get them from someone else or write to me and I will send you a copy. Now, if Bill Halliwell is ready with the slide projector.

HALLIWELL. Yes, I'll turn it on for you.

BERRY. Well, I'm not quite ready. I want to say that what we hope to cover here basically is the two techniques of artificial insemination. Both Stan Temple and Dr. Walter Morgan from State University of South Dakota, will demonstrate the massage technique on chickens. I will talk about cooperative insemination in the American Goshawk, a technique that does not require massage or manipulation of the gonads. Fran Hamerstrom is also on the committee and she will discuss the techniques that she has applied to the Golden Eagle. Perhaps the easiest way for me to show you or explain the technique of cooperative insemination is to show you some very few slides. If we can have the lights now we

can begin.

Before there can be any cooperative insemination there must be a pair bond established between the researcher and the experimental subject, in this case a female Goshawk which was raised in captivity as a household pet. She is four years old at this time, and she is accepting a stick from me in probably the same fashion as she would accept sticks or food items from a male Goshawk. She builds her own nest. She fulfills all the requirements for a natural mating except, of course, she does not have a natural mate. All during this nest building stage and during the period of copulation which precedes the eggs, incidentally, by about three weeks, she is extremely defensive about other people, other human beings than myself, and against conspecifics. In this case the male Goshawk, which happens to be housed in an adjoining chamber and is also what we can refer to as a conditioned or imprinted eyass bird. The male also builds a nest and carries out at least the prenesting cycle. I have never given him youngsters to raise. But I presume he would probably incubate eggs in the same fashion as the female. The male was conditioned to ejaculate semen voluntarily. I started in February to condition the male. He was four years old and had never displayed any indication of sexual response. There was no display in previous years, no chirping, and no territorial aggression. I merely started feeding him from the fist. He was a typical eyass Goshawk. He mantled violently and he attempted to escape with the food. Within two weeks he stopped mantling and within another week he started chirping towards me. Within a month when I gave him the food he would hop off two or three feet, and he would hop back to me and give the food back. He would step off, look at it and chirp. He would stick his tail up in the air and chirp some more. So I knew that he was coming into breeding vigor. When I approached the cage, his tail would be straight up in the air as I think you will see in another picture and he was chirping violently—all the time being completely and totally hostile towards the female. The female was doing the same thing at the same time in the adjoining pen.

VOICE. They could see one another, is that right?

BERRY. They could see one another during the 1970 year. This was duplicated during the second year with no visual contact between the two birds, and they behaved precisely the same at the precise same time of year. They displayed vigorously. He was obviously very excited. One day I was in there feeding him in the early evening which was my general practice and I put a paper bag full of food on the ground next to me and I went to feed the female. He came down and attempted to copulate with the paper bag. That evening I was devising all sorts of artificial female Goshawks in my mind, trying to figure out how the devil to get semen from him. I didn't want to handle him physically because one of the very important aspects of maturation of the gonads is the absence of stress. I feel that if you grab a bird you are going to have one chance and only one chance to take semen. So I was trying to devise a technique whereby semen could be taken without shaking him up. These are actual photographs of his first clumsy attempt to copulate with me as the mate. This is the bird landing

on my leg. Notice how his feet are balled up so that they do not damage the mate. He is calling violently. He kind of works his way down to my shoe. This is a trifle bizzare, but it works [laughter]. Now he is down on the shoe. He is just about to copulate with the shoe as you can see. This is actual copulation. The wings are down. He is on his tarsi, he is straddling the shoe. And his abdomen is revolving in a circular fashion and pressed down against the shoe. This forces the papilla to penetrate the panel feathers, the papilla being the rudimentary copulating organ in a bird of prey. They have no structure comparable to the mammalian penis. So this papilla is forced down against the shoe which of course would be pressed against the female's cloaca or the everted oviduct in natural mating. This is immediately after—I guess this is a withdrawal process, a sort of post-copulating depressive mood [laughter]. It wasn't very many days until I devised a workable technique and sort of mutually agreed that my hand would be the desired copulating object. I would go in to his chamber, place my hand and fingers on this block which was his feeding block at about a 45 degree angle and he would fly to the block, placing one foot on one side of my hand and the other foot on the other side and copulate with the back of my hand.

VOICE. Facing your arm?

BERRY. Facing my arm. Exactly the way it occurred right here. He literally works his way right up on the hand, the papilla penetrating the panel feathers. I guess it's about a quarter of an inch long. It's merely a lymph fold. I imagine Stan could probably fill you in on this.

VOICE. Is it just blood that distends it?

TEMPLE. It develops during the breeding season. Not blood.

BERRY. But it has some erectile tissue in it. It is not very much. It is quite short. But anyway this lodges between the fingers, and he ejaculates. The semen is collected from the fingers in a tuberculine syringe and taken to the female. Maybe you can see it better in this picture, a better idea of the way the feet are balled up and he gets down on his tarsi and so forth. During the 1970-71 season we went through this routine 117 times. We only got semen 15 times during this whole process. There are many, many, many dry runs preceding a one-week period during which you get most of your semen. And the week period corresponds precisely to the egg laying period of the female. Collectable amounts of semen were only secured three times during the 1970-71 season. Three times for each season.

VOICE. How much is collectable, cc-wise?

BERRY. Collectable semen amounted to about 0.02 cc which is equivalent to about a good sized drop of water. Very, very small amounts were ejaculated. However, examination with a microscope disclosed the semen was very concen-

trated and very motile. When I approached the female Goshawk, she assumed a precopulatory posture. This is taken with a telephoto lens. When I was 40 or 50 yards away the female would become quite excited and fly to the door of the pen. She assumed this position with her head down and her wings out a little bit. The only physical part of this whole routine by me is the stroking of the female on the back which stimulates her to spread her panel feathers and expose the cloaca. Actually right there I am not really working with the cloaca, I am palpitating the bird to find out just where the eggs really are in the bird. You can feel an egg as the abdomen extends. It becomes enlarged about two to three days before an egg is laid. You know when that egg is coming. For maximum fertilization, insemination should be 36 to 48 hours preceding that first egg. This photo illustrates the minimal stimulation on her back. You notice the tail is going the other direction and unfortunately the wing in this particular picture is drooped down to support the conspecific male, obscuring the division in the panel feathers. She is actually exposing her cloaca. She just wouldn't tolerate anybody else around when this whole thing was going on; I can understand that. Generally I would do this with the left hand, the minimal amount of stroking of the back, then I would grasp the tail in the left hand and lift it up, exposing the cloaca. In this picture there is no eversion of the oviduct. In the year 1970 there was no eversion of the oviduct. The syringe was placed in the upper left hand portion of the cloaca and inserted about ¾ inch. The left side corresponds to the functional left oviduct in a raptor. In the 1971 year the cloaca turned inside out on the bottom exposing the small orifice of the oviduct. In the 1971 year the semen was placed about ½ inch into the actual oviduct. It didn't seem to make any difference because there were four fertile eggs in 1970 and three fertile eggs in 1971, 100% fertility in both years.

THACKER. Bob, when you took the semen specimen, did you immediately run into the next pen and implant it?

BERRY. Immediately. The semen was immediately transferred and was not diluted. There is always residue. If you collect perhaps .03 cc, there is always some residue in the syringe which was mixed with physiological saline and given to the bird about 15 to 20 minutes after the original insemination.

VOICE. Did you give it three times in a row then for three days?

BERRY. No, if you got one of those papers, it shows that the maximum, the optimum insemination occurs a day or two before each of the eggs. With probably any one of those inseminations the whole clutch would have been fertilized.

THACKER. Did you do any motility work on the semen, any work like that?

BERRY. Yes, Motility with undiluted semen did not seem drastically altered after three hours at room temperatures. After six hours motility obviously de-

creased and perhaps half the sperm no longer moved. At nine hours, 90% of the sperm were immobile and the rest were not very active.

TEMPLE. I have got a lot of data on that.

BERRY. OK. Let Stan worry about the motility. This is the first chick hatching. The chicks were hatched in an incubator and given back to the adult female to raise. At just one day of age here is the huge Goshawk feeding the tiny little chick. She was allowed to incubate one of the eggs for 31 days. I gave her this chick and took the egg away from her. The next chick was hatching three days later and she was given the second chick, and six days after that the third chick hatched. I allowed the third egg to remain in my study for several days hoping to get her to recycle. So perhaps a rather bizarre technique. It's something that you certainly can't practice with the ordinary raptor. But I do believe it can be practiced with most any imprinted raptor that is properly conditioned to accept you as mate. And I think probably the only requirement for this is total and complete isolation from other raptors and of course a lot of communication between you and the bird during the normal process of maturation of the gonads.

Stan Temple, would you present the massage technique of artificial insemination?

TEMPLE. I think I'll comment a little on my work with cooperative insemination first. This was done with Red-tailed Hawks. It's the same basic type of procedure—there's not much you can vary in the procedure. I would comment on this imprinting technique. Imprinting in birds is accomplished very early in their life. And when we use "imprinting," we hear that the bird has become fixed on some object during its early development in the nest; and it will come to regard that object as a conspecific, something it should associate with. We do this—falconers do this all the time—when we take a young eyass from the nest and handraise it. The bird sees you and thinks of you as its parent. It becomes imprinted to you, it thinks that you are the type of object that it should regard as a parent image. The next thing, when a bird has regarded you as a parent image—as long as they are kept away from other members of their same species—the next step in this progression is for them to assume that you are a social partner, and falconers do this by hunting with their birds, by manning them and by hunting them. The bird cooperates in a social interaction, hunting, which is a partnership between you and the bird. The next logical step from a social interaction, when the bird becomes sexually mature, is a sexual interaction. And this imprint is nothing unique to birds of prey; all birds will do this. Most of you, I think, have probably read some of the popular accounts that have come out on territoriality, like Konrad Lorenz's *On Aggression* and so on. Ducks, for instance, have a following response when they're imprinted. You raise a duck from hatching and it sees you and thinks you're its mother, and it'll follow you around. These ducks, when they're imprinted, will also do exactly the same thing that we have happening with birds of prey—they'll become socially and

sexually fixed on human beings.

I repeated essentially the same type of technique that Bob had. I had a male that was 14 years old. He started copulating on my gloved hand, putting semen on the glove when he was four years old. It was way back when I was in high school. However, I was never able to get a female that would lay eggs—and of course, this is one thing we should stress right off the bat in artificial insemination. Artificial insemination isn't worth a darn unless you have a bird that has fully functional gonads. So the male would copulate fine with the glove. We could collect semen. I might say that the male Red-tail produced semen volumes and frequencies that far exceeded Bob Berry's Goshawk. I collected semen daily and I had volumes that ranged from .1 up to almost .4 cc. This is a big drop, not a little drop. I injected it daily into the female, The female responded the same way to stroking her back. This female was a little different, she'd let anyone stroke her. This may have been because Bob was the only person who handled his Goshawk, whereas this bird was handled by many people. Two fertile eggs were produced. One hatched by artificial incubation. The other was put under a broody hen. I'll have more about that later. So basically what I would like to emphasize is that falconers as a group probably have many birds that, given the right amount of handling, are likely candidates for this type of work with artificial insemination. Most of these birds have been taken as eyasses trained for falconry and then retired. You saw Bob Berry handing a stick to the female. It is very important that you go in there daily and help them build their nest, stroke them. Be around so you strengthen the pair bond. The other thing that I tried last spring was manual ejaculation of the male. I knew that my male Red-tail was in full reproductive condition. Therefore, I thought it would be valuable to try a forced ejaculation technique. Now this massage technique is a little deceptive using it on a bird such as this Red-tail that will ejaculate voluntarily, because it doesn't take much to get him to ejaculate. But I decided I would go all the way and try doing just like you would have to do to a bird that wasn't going to ejaculate. I trained the bird so I could lift him up holding him by the legs. Unlike Bob Berry's bird I did get my bird right in the middle of production. It didn't seem to bother him at all. He had to be trained very much like you train a Cooper's Hawk to sit on the hand. The training technique involved first holding his wings closed; forcing him down on my lap; holding him there for a few minutes and offering him a bit of food as I let him up. Much like breaking a bird to a hood. After about a week and a half of this there was no stress at all involved with picking him up right off the perch and holding him. He just didn't seem to mind it at all, once he had been broken in to it. The bird was held by the legs; the cloaca was exposed, and the technique that we will show you after we are finished here with chickens, because we don't have any raptors in breeding condition, worked very adequately on him. The technique involved physically pulling the papilla out and what you do is strip or pull the semen out of the very end of the sperm duct—the seminal glomulus. This is where the sperm is stored before ejaculating. Using this technique, this forced technique, I wasn't able to get as large an ejaculate as I was with the voluntary

technique. The ejaculates were much smaller. They ranged down to less than 0.1 cc, more in the range of what Bob was able to get using the voluntary technique, but I was able to get perfectly viable semen that looked in every way healthy, just like it would in a normal ejaculate from a hawk. There is one other technique that can be used for collecting semen, and this involves the technique called electro-ejaculation. This technique is used frequently with farm animals, bulls and rams and hogs. It involves giving the bird an electric shock. What you are trying to do is cause the muscles that squeeze the seminal glomulus to cause an ejaculation. You are causing those muscles to contract violently and force an ejaculation. You all know that you get a muscle spasm when you get shocked. The machine that was used is right over here. Basically, it is a pair of electrodes. You control the voltage and the amperage of the shock that you give the bird. They found doing work of this type with chickens that approximately 30 volts at a range of about 1/10 or lower amperage, given to the bird at three second intervals, three to five times, three seconds off, three seconds on, etc., usually stimulated an ejaculation. The electrodes are attached at two points. One electrode is attached to the rump area just above where the testes would be or just above the leg joint. The other electrode is a probe and the probe is inserted right into the cloaca. Give him the shock. This is one drawback perhaps with the birds of prey. It does cause muscle spasms in the hip region, but the bird seems to recover right away. My work has only been with chickens using this technique so far. It seems to be a very good technique for getting semen from a male that is in full reproductive condition but that would not cooperate like our imprinted birds would. I don't think it is going to be necessary to apply this with birds of prey. But I present it here. I have circuit diagrams for anyone who would like to build one and try it on some bird. You can have a crack at it, and see what happens. I haven't yet tried it.

SWARTZ. You found that placement of the cloacal electrode was not critical. I failed to succeed with an adapted ranger electrode stimulator. And I think maybe Skip Walker and Jim unsuccessfully tried it with pigeons or discovered that placement was critical.

TEMPLE. Placement is critical, yes. What I did was bypass the papilla. If I had a blackboard, I could make a diagram. The papilla is on the ventral side, the lower side of the cloaca. You can think of the cloaca as being like a rubber glove and the papilla rolling out like you sticking your finger through the rubber glove. Sticking it out through the cuff, sort of like that, the papilla comes out; you insert the electrode back almost into the rectum of the bird. It's behind the papilla so that the placement of the electrode isn't hindering the papilla from being exposed.

VOICE. Are you trying in essence to get it as close to the testes as you can?

TEMPLE. No, no. The idea is not to get it close to the testes. That's not it at all. You are trying for the muscles that control the seminal glomulus which is the area of the sperm duct just before it gets to the cloaca.

SMYLIE. Do you use any kind of anesthetic while you are doing this?

TEMPLE. You can. If you put it on your own hand you can feel what it's like. When you get it in contact with the muscles as you are by clamping it, you get muscle spasms. It's not the type of thing that is . . .

SMYLIE. What about trapping a wild raptor. Anesthesia . . .

TEMPLE. I wouldn't recommend it, no.

SMYLIE. I was just wondering if any experimenting has been done with birds that are not tame.

TEMPLE. Yes. This technique is one way. They have used it with uncooperative and untrained birds. But the thing I'm saying is that even for an untrained bird, you can get the bird to ejaculate using the massage technique that we will demonstrate later on. In fact something that Fran Hamerstrom alluded to in a little note in *Raptor Research News*, it can be used effectively. The one other thing that I've got some information on I think is rather unique information, since it's probably the only case where we've gotten enough semen from a bird of prey to try to use a certain diluent for preserving the semen. Let me put this slide on. I was able to get enough semen from a male Red-tail that it was worthwhile to try some very simple experiments on how to extend the life and to dilute the semen so it might be able to go around to between seven or eight more birds. There are two—think of them as things you can dilute the semen with or perhaps preservative—that are very easy for you to prepare. Most extenders or diluents that are used by the poultry industry are not the type of things that it would be very easy for the average person to put together. To make up I tried two that are very easy. I tried Ringer's Solution which is a physiological saline type solution, the mixture of which you can get out of any standard physiology book. And one that has worked with chicken semen and turkey semen is sterilized whole milk. I diluted the semen in 1:1 dilutions—one part of semen to one part of my diluent in each of these trials, and I compared it at two different temperatures: ice box temperature about six degrees C and body temperature at about 40 degrees C.

What I looked at here was how well the semen survived under these conditions as compared to undiluted semen. Can these techniques be used perhaps to extend the life of the semen sample so that we could ship semen around the country to different people. What I did: The semen in a good ejaculate is very dense, and the individual sperm cells are very active. It's a very simple-minded type of experiment. In a microscope field (under 430 power) I placed samples of each of the different treatments described above. In each field of view I counted 100 sperm cells. Out of the 100 I counted how many of these sperm cells were dead, the ones that were not at all motile, the ones that were not moving at all. I then did that, initially. The first column here is undiluted

Table 1. Semen Extension Experiments (after Temple).

	Percentage of Dead Cells		
	0 hrs.	3 hrs.	6 hrs.
Undiluted at 6 C	0	21	30
Undiluted at 40 C	0	39	54

semen (Table 1). This is fresh semen that has just been collected. Zero hours of collection I found no dead cells of the 100 cells counted; three hours later undiluted semen at six degrees 21; at six hours 30. So that by six hours after collection at six degrees about a third of the sperm cells are no longer functional. At 40 degrees body temperature, this is much worse. The three samples were 0 at collection time, 39% at three hours, over 50% at the end of six hours 54% were dead. Obviously, keeping it cool but not frozen is the best way to do it. I also looked at sperm motility. What I did here is a very simple thing. I picked 10 random sperm cells in the microscope field and scored their motility—how fast they were moving, how vigorously they were moving. I scored it 0, 1 or 2. Two if it was very active; 1 if it was moderately active; 0 if it was practically inactive. I then got a percent of what full activity would be for those ten. It's 100% right away after collection. It drops off to 40% activity, which is pretty low really. If you get anything less than half of that motility, you might as well forget it. The activity is probably so low that the sperm is not active—even worse with warm semen, 100% to start out with. It goes down to six hours with only 10% activity of the sperm cells. That's what happens when you are using undiluted semen just as you collect it. If you dilute it with Ringer's Solution, the same thing occurs, generally. I think I won't go through all these data. You see that in both cases it is worse. Ringer's Solution didn't do the trick. It didn't extend the life of anything. The sperm motility drops right off, much sharper than it does with undiluted semen. Actually, approximately the same for warm semen, but this is a small sample size. There is only one sample, so you can't really say. Sterilized milk is merely milk that has been heated to destroy the lactic acid in it, which is harmful to semen. And here the results are roughly comparable to the Ringer's Solution. Still nowhere near as good as undiluted semen. The only thing you can say is that at higher temperatures these diluents did seem to preserve motility of the sperm a little bit better. OK, you can have the light on now. I want to emphasize that it is probably not going to be very practical to send or distribute avian semen, raptor semen, through the mail. In other words, if someone has a female in California that is laying eggs and someone has a male in New York that they can collect semen from, it is probably not practical to send it to the fellow. Probably if you are going to get hawks together the way to do it is to bring the two birds together somehow.

HUNTER. You didn't try freezing it immediately in liquid nitrogen?

TEMPLE. I was advised by the poultry people that it would have been much worse Freezing avian semen is not like mammalian semen where you can quick freeze it and preserve it. Quick freezing avian semen for some reason is very, very hard; it kills something like 90% of the sperm cells right off the bat.

HUNTER. One wonders why.

TEMPLE. Who knows. I might say the literature on artificial insemination in poultry is voluminous. People are just working on this. The publications are in the hundreds every year. They are actively working on it with some of the wildest diluents you could ever imagine. Stuff that is carbonated and aerated. It's unbelievable what they have tried. So I might also say if any of you want to try this massage technique, we are going to show it in a few minutes, on any of your birds that you think might be in reproductive condition, there are a couple of things that you can look at in the microscope to tell whether it's a good semen sample. We're going to show you a couple of these things.

BERRY. We are going to look at some of the semen under the microscope in back after Dr. Morgan shows us the technique. If you're done, Stan, thank you very much. I think we have to hold questions, we just don't have the time. Dr. Morgan has a tight schedule. Fran, could you take the floor and tell us your experiences with the eagles.

HAMERSTROM. Bob Berry asked me to talk on the massage technique. I had never heard of it. We always called it rough artificial insemination. I have successfully gotten semen from four species: Horned Owls, Red-tails, Golden Eagles and Broad-winged Hawks. Some of these birds were prepared in advance. Others were fresh caught wild birds. We just grabbed them and got semen. I'll tell you how one does this assuming you all know how to catch them in the first place. You grab their legs. If it's a Red-tail or smaller you put the legs between your knees with the bird's back up. Then you start stroking its back and putting pressure on its belly until the tail comes up. Then you slip your fingers on either side of the vent. If it's a male, out comes semen, if that male was just about ready to copulate. With the Golden Eagle one prefers to have several assistants [laughter]. I tried it alone for quite a long time. And my eagle kept mounting me and fortunately not my little hand. I would rip off my jacket and look at it carefully to see if there was semen on it. I had some disadvantages that you didn't all have.

I would like to talk about some of the things that work up to semen production. You can use a combination of these things. You can do all this coaxing at the beginning and then if you need semen because you know your female is about to lay and you can't get it by the cooperative technique, why you may wish to resort quickly to the massage technique. What leads up to this? In the birds that build stick nests, it's playing with sticks. Tease them. Don't let them have sticks all the time or you will lose your advantage. This works with owls, and I don't think it works with falcons. They don't build stick nests. They are

not fascinated by sticks. I think they are fascinated by things like wings of pigeons. I use my voice working with the eagle and neck stroking. My Red-tail copulates first on my ankle and after that he much prefers my head. My Horned Owl copulated only once and that was on my head at night [laughter]. My diurnal raptors tend to copulate first thing in the morning. Then they're keen on it and then again late in the afternoon but their enthusiasm wanes near noon. With the Golden Eagle you have to wait about 20 minutes between attempts to get semen. If you fail the first time, go get coffee—spend 20 minutes doing something else and then go again. With rough artificial insemination I am using the equivalent of that little box but it is cheaper. You just take the bird and you keep stroking and you keep working and you get exhausted both emotionally and physically, because you think you are being rough on the bird. And just about the time you want to give up, the bird bates. That's when the semen comes, right at that bate. That's when you keep going. This is the quick shot treatment. When that bird has had enough of this monkey business and wants to get away is when he is going to ejaculate semen. I'd like to clear up one thing. I have a paper in *Raptor Research News* (5(3):91, 1971) on semen extenders—a recipe for it. My purpose for semen extender was totally different. It was, if I didn't get enough semen, to extend the quantity rather than the time. Now if we could show my slides, that would be very fine. I might mention that I have a paper coming out in *Die Vogelwarte* on the male Red-tail's capabilities. And the Golden Eagle material is largely in my book. (I would like to give one bit of advice to breeders. When you go in for any of these monkey-shines, take the bird away from the breeding pen if you are going in for rough artificial insemination and then walk the bird back to the pen. The bird will forgive you in about three paces while you are carrying it. There is nothing more soothing to a bird than to be carried.) Could I show the slides, please. Here is my Golden Eagle, Grendel. He is a little uncertain but it is early in the season. He is preparing to mount. You cannot imagine the conversation in the Hamerstrom household. This happened every day after breakfast. I would go out and get mounted. I'm the very absent-minded type. Sometimes I would go running out in a little thin sweater or something or other and my husband says, "Fran, did you remember your copulation jacket?" [laughter]. The bird is really cued in on that jacket. At any time of year I believe he will mount me or show considerable interest if I have that on. Next. Here he comes flying. And eventually he gets up onto my head. I think that's next or there aren't any more. I don't know which.

Oh, yes, preparation for artificial insemination. I go and catch the bird. This poor chap comes to our place, and he had never seen an eagle near to before and he said, "Oh, I wouldn't want to get near that;" and in about five minutes he was helping because we were short-handed. Next. He is picking up the bird. This is the female, and I always run away because I don't want to spoil my beautiful relationship with that female eagle, Chris. So I watch from the window. I may be foolish but there is no point in taking a chance. Next. I've gotten five eggs out of her in one clutch. And it brings me to a point I would like to make. Consider the possibility of not just recycling. Consider egg stealing. My hunch is birds of prey are far less determinate than we have supposed. And you may get

more eggs. Put the first eggs in an incubator or under something else. But consider this possibility, too. Some experimental work needs to be done on it. Artificial insemination. Two professors from the poultry division of the University of Wisconsin. I always admire their courage. They handle eagles as though they are turkeys. Until finally they saw my man get nailed. And then they had a very different viewpoint. Next. This is about two minutes after a really rough go. Two attempts at getting semen. The second was successful. Everybody was exhausted. And if you notice the eagle is perfectly placid. They get over this right away. And so do my other birds. Next; good, that's the end.

BERRY. Thank you, Fran. Can we now have Dr. Walter Morgan come up here for a minute. He has hopefully a few comments or recommendations and suggestions.

MORGAN. I'm happy to be with you today. Brookings is about 60 miles north of here, and my schedule isn't really so tight. There are a few comments I'd like to make before the demonstration. Actually I don't know if I am going to stand on these chairs or what. I was sitting in the back row, and I am a little sympathetic. It's kind of difficult to see the demonstration; I am afraid it will be quickly done, and we will have the result from it, and we won't have gotten enough information from it. First, we might ask when is artificial insemination used. And we use it in poultry for special single sire mating when we want a particular male, a lot of progeny from that and known identity. We use it if we have cages. If we have birds in cages which are breeding birds. Normally we had floor matings for many years. Now as we use cages more, we do not mix the sexes often. And we can use artificial insemination as a fine tool here for when the sexes are separated. We can keep a pen of males. When you put a group of males together after they are sexually mature normally they are going to start fighting. But if you rear them together, the males will be harmonious and you can take one male out, collect semen, and put him back in. Nothing will happen. There are more copies of this if anyone needs them. Another kind of artificial insemination that is used and commercially it is used very much now in turkey production. Practically all of our turkey producers use this. The reason for this is that the geneticists have done such a good job in breeding for big full breasts and for short legs and for meaty legs that the male Tom turkeys are not able to mount the hens any more. This is kind of ridiculous to breed for one specific desire in our economy to the extent that natural matings are not likely. The more successful breeders I think have the natural breeding plus artificial insemination. Some of them use only artificial insemination. Considering when it's used, we consider when there is maturity. What Stan said was true about having to have mature birds before you can collect any semen or before it is worthwhile to inseminate them; at least they should be inseminated a short period before they come into production. Now with turkeys for instance, the pens of the males are lighted for about a month—they have artificial illumination. The day is lengthened artificially about a month before the semen is collected. This way spermatogenesis is complete and mature sperms are produced.

With the females, about the same time is needed.

Why is artificial insemination used? One reason for using it is precision so that you know exactly what male has been mated with what female. I think that is important to all of us here. The raptor breeders. For establishing genotypes, for establishing what particular lines for selection you might want to have. To overcome natural mating obstacles. And it seems to me that that is what the whole bag of tricks is about here. And to conserve space by using artificial insemination if you have them, for instance, in cages.

As far as storage of the semen is concerned, the duration of potency for chicken semen is normally about three or four hours, if it is in vitro. After you have collected the semen you have two or three hours, three hours perhaps, to inseminate. You can carry it around and move it if you want to. But as Stan indicated, you cannot ship it long distances. We do not yet have means of preserving semen the way they can, for instance, bull semen, where they can use it a year and a half, perhaps 20 years after. I don't know how much longer, after they have collected the semen. But we can only use it a very short period with poultry semen. I think that the longest that it has been demonstrated is some semen was sent from Maryland, College Park, over to England. They inseminated some hens there. But it was a very rapid trip in less than two days.

One of the cautions that I would mention to you, and this stems from some work which I did in Belgium a couple years ago. I had an opportunity to work quite a bit with semen motility at that time. First I mention that, in order to be potent, good semen has to have good motility. But the opposite is not true. If it has good motility, this does not mean that it is potent semen. I was interested in what dead semen was in your slides. A lot of us think of semen that has lost its motility as dead semen. We had some irradiation studies over there. When semen is irradiated with over 4,000 roentgens, semen that had been ejaculated, it lost its potency but it had good motility. We had semen that was control semen that had not been treated that continued its motility for up to 10-12 days but it was not potent the first day after it had been collected. So you can see motility, and it's not necessarily a criterion for saying that it's good semen. Some of the cautions that we take with artificial insemination are that we have to watch for the quick ejaculator. I think you have been exposed to that in the discussion that we have had before. Sometimes after you have been training the male, training the roosters for a while, you have them in the cage. You reach in for them, if you happen to hit them the wrong way—it's gone like that. You haven't even put your receptacles, your collector up there to get the semen.

Another caution would be cleanliness of your operation. Now I have distributed a page telling what the procedures are going to be. I also have here the equipment that is necessary for artificial insemination. Normally we use a pair of scissors, any pair of scissors, to cut the feathers off the rooster around the vent on the abdomen. The reason for this and the only reason for this is visibility, so you can see what you are doing and can have a clear field to work with. For our chickens this is a good type of collector to use. It's a plastic container, for turkeys and for chickens also. The normal amount of semen that we collect from a well trained male will be up to one cc. We need approximately, or nor-

mally use, .2 cc for each insemination. So that if we have a good producer of semen, we can take care of five hens without using an extender or extending the semen. The semen in hens will be effective for a week. Now I don't think there are any cases with good semen where you need to inseminate more frequently than a week. A week apart for inseminations is good. They can last up to two weeks, possibly to four weeks. In the turkey the semen insemination will last for practically the whole breeding period. So we have differences in species. And this is something you are concerned with, but you have such a small clutch with your raptors. I would suggest that a good insemination a day or two before they start laying would last for the whole clutch. There is no reason to be concerned about multiple inseminations. I'm saying this off the top of my head without a lot of knowledge, but from the experience we have had with chickens. The amount of semen that is inseminated is important because you probably won't have too little semen; you may have too little semen in chickens. If you have 0.2 cc, mainly you have enough. It is protected and maintained within pockets which are in the oviduct. And the actual insemination takes place as the egg is ovulated from the ovary as most of you know, as it starts down the oviduct. And these little individual bits of semen are available to fertilize if another egg is coming. So it is a matter of livability, if you want to use that term—viability. I would rather use viability of the semen after it is in the oviduct. In turkeys we find it lasts a long time. In chickens it doesn't last for such a long time. Now the tools that we use for collecting the semen. We collect it in a small tube. After it has been collected (this is ABC on your handout) we transfer the semen from the tube that we collect it in, into a syringe. And normally what I do in practice is take out .2 ml for each injection insemination, because if you have .8 out and you try to inseminate .2 down to .6, it is quite precarious because you have to try to look at it, it's pretty difficult. If you just have .2 in there and make a complete plunge you are all set. Those are really the only instruments that you use. In addition to those today, if we can we will set up a demonstration of motility and for that we use cover slips and depression slides, and I have the slide here. It will probably be five or ten minutes after I finish the demonstration that we will have the sperm available to look at the motility.

BERRY. Dr. Morgan, would you comment on temperature shock?

MORGAN. Temperature shock on semen?

BERRY. The outside temperature when you collect semen. Should you take precautions before transferring it to the female?

MORGAN. No. I would reiterate that in storage the coldest semen retains its motility much longer. In the samples that we used we had it refrigerated temperature. But retaining motility doesn't mean retaining viability. They are more heat susceptible than they are cold susceptible. I would make that comment coming from body temperature they go to the cooler room temperature and

this is fine. So I don't think any precautions need to be taken there, if you do it within a couple of hours.

THACKER. Dr. Morgan, would you recommend sterilized equipment?

MORGAN. I would, yes. I would be sympathetic toward the posture of the veterinarians and I would say that sterilized equipment is highly desirable. I do recommend it. In practice I don't follow it at all times. I've been fortunate not to have problems. I could use those chickens if somebody wants to bring those boxes up and that lab coat that's there.

BERRY. I was looking at semen under a microscope. Extended over a period of hours, I noticed that some sort of growth appeared in the semen. It was almost like they became too crowded to swim after a while. Something was growing in there. Was that bacteria?

MORGAN. There is a clumping of the semen which I've noticed, they clump around the semen.

BERRY. They clump around that, what is that?

MORGAN. It's some kind of starch artifact, I don't know what it is.

HUNTER. Greg Thomas is going to take this on video tape. We are going to kill two birds with one stone if you will excuse the expression, demonstrating closed circuit TV.

MORGAN. What has been done previously to these birds—you recognize that they do not have all their feathers. The first two here are trained males. I hope they produce. They have been clipped. The third one I will clip and it hasn't been trained. I have less hope for good results with the others. Now you will notice on your sheet that this can be done with two operators or one operator. Frequently they have one person hold the bird and the other person stroke it and collect the semen. I have come to do it as a single person operation, and it normally works pretty well. The testes as you know are in this area of the bird up near the back. Stroking of the back like so produces the ejaculate. Now there is some fecal material there. And there is a sort of stripping of the duct that I think Stan mentioned in some of his birds, too. Usually after you have tried it three times and if you haven't gotten anything, then you might as well give up. He produced a pretty good supply of semen and there was some fecal material in there as well. So this sample you would have to let the fecal material sediment down to the bottom. And I will remove it with a syringe that I have here. As I said, it is anticlimactic because it is all over. I'll remove the semen. Now that one produced about 40 hundredths cc of semen.

GRAHAM. How much pressure did you use on that?

MORGAN. I put a lot of pressure.

TEMPLE. I have an untrained rooster that any of you can practice with.

HUNTER. I have 300 of them.

MORGAN. OK, there are some things, the first was without telling many of the particulars about the technique. I think with your raptors you'll have different types of reactions than we would have here. Reactions in terms of methods of holding them. For this I put my little finger between the legs, hold the legs and have the container near the cloaca. Now, actually, I stroke him two or three times, and then I push down; and I'm kind of pushing up on the abdomen, too. If you can watch and see that perhaps, stroke him like that. Now that is fecal matter, that's not semen. I hope you didn't get a picture of that.

VOICE. Is this a trained bird again?

MORGAN. Yes, this is one of the two trained ones. There is quite a bit of fecal material but there is a good supply of semen, too. We'll set this semen up under the microscope.

I will demonstrate now the insemination into a hen. And for that purpose I will return some of the semen into the container. It is a very simple process. The semen is not as clear as I would like it to be. So whether it's our personal relationship I'm not sure. Now this rooster has all of its feathers, you see. He hasn't been clipped or anything. It's possible to collect semen without clipping them, but I like to clip the feathers off. Whoops [laughter]. It is a little bloody. There is a little bit of semen, there is a very little bit. But there is some. This is normally what we would expect. You can see where it drained down the sides here. We would expect to get a little bit the first time and an increase with daily trials. I'll set up some of this semen.

TEMPLE. While you have that chicken, there is a technique that I use on other birds such as pigeons. This seems to work a little better for me, a little better to have someone hold it and hold the tail up and massage the back. Then for actually stripping the bird that is going to be very uncooperative, like for instance a hawk that's not imprinted. Using the other hand and approaching ventrally instead of dorsally is to reach in until you can feel the end of the papilla and bringing it out; he has just ejaculated and just sort of letting your fingers slide along. I don't know, for me that seems to have gotten more from an untrained bird than just the stroking of it. You might want to comment on that technique. Is that common to pull the papilla out?

MORGAN. The chicken has about as little papilla as any of your raptors would. They are practically without it, too. If you have a duck or goose, they have a nice long one. You can really strip that. There is not much to strip a raptor. And I think there isn't much to stripping chickens.

TEMPLE. It's small, pulling it out.

MORGAN. I put it in my notes here—manipulation is stripping of the duct, so we have that in common. I would be optimistic about these techniques with your birds particularly after hearing what we've heard with previous two speakers. It's a really simple technique. It's something that you work on—well, if you know when the female is going to start laying, you would start on your male a week to 10 days or maybe two weeks before that. Then if you inseminate, if you're able to inseminate her, just before she starts laying, you are through in two weeks. So it's not a long tedious process. And if you can collect semen, the insemination of the female is extremely easy.

GRAHAM. Would you explain in more detail just the pressure you used and exactly where when you stripped.

MORGAN. With the hens there is quite frequently, there usually is, an expulsion of fecal material. Now, for holding the hen normally, I rest her on my thigh like this, too, and her feet will go right on my thigh. And I will press down on her back when I get ready because I will need all my hands to manipulate here. The hen has as mentioned previously, an oviduct. With the chickens the oviduct everts. There is quite a large opening. It is just a matter of putting the tube into the everted oviduct. That's mentioned on your sheet; it's really mentioned there better than I can say now because you relax after you have inserted the syringe. And when the hen has relaxed, I push the plunger. And in all this we also realize the sensitivity of the birds we are working with and we are trying to avoid stress. I think I use the word effort in the first line there; several places I said without too much effort, or without much effort. Without stress, I am trying to say. I encase her head under my arm and go in like this. There is some fecal material there which is interfering with the oviduct. There are two openings. You see there is an oviduct and there is also an anal opening. You have to insert it into the oviduct. We have had some chickens in Brookings which had two oviducts. This is a genetic difference where they have a right and left oviduct. Very unusual. Normally, they just have the left. If they have two oviducts and we have inseminated into the right oviduct, we have never had any fertility. So it should be into the left functional oviduct. And I noticed you said you went on the left direction when you were into the raptors so this I would expect, so this is as it should be. If anyone else would like to practice with these, why they are welcome to, I consider it kind of a challenge for Don saying that he wanted one that was untrained and I didn't know they were going to bring one; so I have one that is untrained, or I'll take his.

In the training period these have been trained for about a week. I have a student who works with me on this. And the first time that he tried it, there were 15 roosters, and four of them ejaculated semen. So it is not unusual to ejaculate the first time, to get semen the first time.

EBERLY. How do you train them?

MORGAN. Just by trying to collect semen from them. This is what the training is. I would expect this would be true in raptors. You would have to train them. I have heard several people speak of the very precise and close association people have with raptors. Perhaps this is a necessary part of it. But at least with chickens any of us who try it can usually get results if we use the proper technique.

OK, as I strip this male, I've got the tube in my hand so make it all realistic. I like to have him kind of sitting down like that just like the hen was sitting down. Then I can bring pressure to bear up here and with this hand I am pushing down here. I am pushing on the abdomen and with these two fingers I am stripping in here There is quite a bit of pressure that is given in the excitement. Here I think one of the dangers I might be suggesting, that we might be reluctant to squeeze them too much. You do squeeze them quite a bit. I've found with students that they think maybe I am hurting the bird.

VOICE. As hard as a hand shake? [laughter]

MORGAN. Yes, at least.

VOICE. When you get a small amount of semen coming down the side, do you use a dilution material to get that out?

MORGAN. This I let settle for quite a while. This will eventually settle, maybe after two minutes. Then I try to pull what I can up into the syringe. I haven't diluted it. We don't practice dilution. I'm for dilution. I think it's OK. But we haven't needed to use dilution.

VOICE. You get just that little bit that you got out of that first ejaculation. Will that be enough to draw up?

MORGAN. No, on this one I didn't have enough.

VOICE. But that's just about as much as you are going to get out of a small raptor.

TEMPLE. Look at a Red-tailed Hawk, a Red-tail gives as much. Bob, you have never stripped your bird to see whether you could get more out.

BERRY. No.

VOICE. Is it too viscous to come up in capillary tubes?

TEMPLE. I tried doing this on Starlings which are roughly comparable to kestrels as to size. I could bring the papilla out and get an ejaculation. And that is what I used in capillary tubes. I just touched it and it was sucked up into the capillary tube. I'm almost certain that if you have a raptor in full reproductive

condition using the stripping technique, you should get plenty. I don't think you have to worry about not getting enough.

VOICE. What about [inaudible].

TEMPLE. I've used a pipette for the insemination; I didn't use a syringe, I used a pipette.

HUNTER. For whatever it is worth, about four years ago he told me that Pheasants were very difficult. I didn't happen to have any chickens at home, but I did have some Pheasants. It was breeding season. A cock pheasant was obviously in breeding condition. I went over and picked him up, got semen from him immediately, it surprised me, quite easily. I never really tried it on chickens.

MORGAN. Some people use a little tube to get a greater distance in insertion; this is particularly true in turkeys, where there is a longer oviduct distance and the sperm really has to go down to the area of the ovary, but usually the sperm is potent enough to do it without this assistance. I am finished then, unless there are any questions

GRAHAM. What about injection of fecal material with the sperm?

MORGAN. We like to be cautious and avoid that but if you do, that will not kill the sperm.

VOICE. [inaudible] bird that is laying eggs already and then you inseminate?

MORGAN. OK. The question is about when there is a delay in when you inseminate, and if I don't give the answer to this, come back to it. With laying hens particularly if there is an egg in the oviduct, this egg will not be fertilized, but the egg that she lays day after tomorrow will be fertilized. The most desirable time to do this in chickens is right after they have laid an egg, because their oviduct is free then. It takes about 24 hours for a new egg to come through. If there is an egg in the oviduct, this does not prevent the sperm from going up though. So it can be done when there is an egg in there. If you do make an insemination today and your raptor lays an egg tomorrow, I don't think the egg is going to be fertile.

VOICE. You mentioned that if you can feel the egg in the bird, it is already in the oviduct, right?

MORGAN. Somebody mentioned that.

BERRY. I think I mentioned that. If you can feel an egg in the oviduct, you could probably get that egg. That's before the shell. You can feel it enlarge long before the shell is laid down around the soft part of the egg. So you can get that

egg after you feel it.

MORGAN. In chickens after the egg is ovulated, it's the yolk which is ovulated, the actual size it's going to be when it's laid. After the yolk is ovulated and has started down the oviduct, it does not become fertile at any time. In chickens we can palpate the egg. You can feel in the cloaca. If there is a hard shelled egg, you know it right now. And that egg will never be fertilized by an insemination today.

MENG. Have you experimented with insemination after an egg has been laid? Drilling a small hole in the shell and putting the sperm in.

MORGAN. I haven't and I think it's impossible.

TEMPLE. Very difficult. People have tried to with chickens and it's very, very difficult to do. What happens is the membrane that's laid down around the yolk as it goes down through the oviduct is very difficult.

BERRY. I think it has been done though.

VOICE. A fellow out in California is doing a lot of work on it right now.

TEMPLE. It has been done. Your chances are pretty slim. I might add, when is the right time to start insemination if you have a hen that is going to lay eggs? On the female Red-tail you can feel the pubic symphysis which is where the two halves of the pelvic girdle come together. It's between the legs almost to the vent. That separates and widens as the female comes to the time when she is going to lay an egg. This is a real easy thing if you have handled your bird when she is not in reproductive condition–you can feel those two bones very close together. When she comes into reproductive condition and approaches the time she is going to ovulate (in the female Red-tail it is about a week before she ovulated) those bones come really wide apart. In the female Red-tail you could put three fingers in between the halves of the pubis. Really opens right up, but you feel it coming apart. Once you can feel it coming apart that is probably the time you want to start your insemination. That is a sure sign she is going to be laying real soon.

APPENDIX: Summary Issued at Conference

PRACTICAL CONSIDERATIONS IN ARTIFICIAL INSEMINATION
by Robert B. Berry

Anatomy. Female: In most hawks, both ovaries are functional but only the left oviduct is functional. Anatomically, the oviduct is comprised of five parts:

the infundibulum (fertilization occurs here), the magnum, the isthmus, the shell gland and the vagina.

Male: The genital tract consists of paired testes, epididymides, deferent ducts and in hawks, a rudimentary copulatory organ called a papillae. Sperm is stored at the base of the deferent ducts (Petrak, 1969).

Artificial Insemination.

Advantages	*Disadvantages*
1. Improved fertility.	1. Stress.
2. Cross breeding.	2. Urates reduce viability of sperm.
3. Reduction in males.	3. Requires a skilled operator.
4. Determine potency in individuals.	

Semen Production.

1. Vitamin A and E deficiency affect spermatogenesis adversely.
2. Coccidiostat at 0.0125% in feed does not affect semen production.
3. While semen can generally be taken from a male fowl at any time of year, one cannot expect similar results from a raptor since maturation of the gonads is a cyclic occurrence (they may expand 200 to 500 times their size during the mating season).
4. Greater semen yields occur in the late afternoon—domestic fowl.
5. The greater the frequency, the lower the yield.

Collection of Semen.

1. Optimum response is secured from a fowl if he is picked up quickly and immediately manipulated—ostensibly before surprise turns to fear.
2. Do not allow semen to cool quickly, even though fowl semen is more resistant to temperature shock than the semen of other domestic animals.
3. The best fertility is achieved within one hour after collection.
4. Maximum fertility in a chicken requires insemination every seven days.
5. Duration of fertility in a chicken is 10-13 days.

Semen Quality.

1. Fertility appears to be correlated with motility, percentage of dead sperm, methylene blue reduction time and numbers of live sperm per unit volume of semen.
2. Fertility does not appear to be correlated with pH, density of sperm and volume of ejaculation.

Semen Quantity.

1. Chicken (large) 1 to 4 cc.
2. Turkey 0.3 to 1 cc.
3. Goshawk 0.01 to 0.05 cc.
4. Red-tailed Hawk .10 to .40 cc.

Dilution and Storage.

1. Many attempts have been made to arrive at a diluent medium and ideal temperature and other physical conditions for the prolonged storage of semen, all without success. Storage beyond 48 hours produces such reduced fertility as to be impractical.

Insemination.

1. Optimum time to inseminate is just following oviposition (egg laying).
2. Fertilization will generally occur the second day following insemination.
3. Maximum fertility in chickens requires insemination every seven days.
4. Duration of fertility in chickens—10 to 13 days.
5. A hard-shelled egg in the shell gland reduces the chances of good fertility for other eggs (easily discovered by palpating the abdomen just behind the breastbone).

Is artificial insemination the panacea we are looking for in captive raptor reproduction? Certainly not! Artificial insemination should be attempted when all else has failed, and then probably only when intraspecific hostility endangers the life of one of a pair. Maturation of the gonads must take place before sperm or egg production is possible—a complex and lengthy process brought about by a combination of external stimuli, including the weather, photoperiod, territory, absence of stress, stimulation by a mate. Therefore, if a pair of birds is physiologically capable of mating successfully, a prerequisite for artificial insemination, then they should be allowed to do so. Exceptions might involve a laying female with a displaying male that appears on the threshold of copulation, but for some unknown reason, cannot take that last step. Extreme care, however, must be taken in the introduction of stress which might destroy the reproductive cycle.

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RAPTOR RESEARCH

Volume 6 Supplement Part G 1972

SPECIAL CONFERENCE ON CAPTIVITY BREEDING OF RAPTORS—A REPORT

Sponsored by Raptor Research Foundation, Inc.
Held at Sioux Falls, South Dakota, U.S.A., November 21-23, 1971.

Part G. Breeding Stock Inventory (Panel 1)

edited by
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Panel Members: Donald V. Hunter, Jr., Chairman, Robert Hinckley, Roger Thacker, and Bruce R. Wolhuter.

HUNTER. The subject of Breeding Stock Inventory is a general topic that we chose as a starting subject. First of all, I think everyone is interested at least to some degree, in what everyone else has done. But to have each person come up here and describe his breeding project would take our full two days, so we have asked that questionnaires be filled out and sent in. As many as came in on time have been duplicated and are in the packet. The first panelist will be Roger Thacker.

THACKER. The paper that you have got in your folder there, I finished approximately three months ago, entitled Estimation of Birds of Prey in Captivity in the United States of America. It is, to put it quite bluntly, now completely out of date because inventories changed so quickly. It is a piece of work that was completed over approximately 18 months of sending out surveys to various organizations and I think in the few minutes that I've got to go through it, it would be best to start from the beginning and just work straight through the paper. [Thacker then went through the paper, which is printed in *Raptor Research News* 5(4):108-122, 1971.]

HUNTER. Thank you very much, Roger. First of all I'd like to stress the importance of finding out how many birds of prey are in captivity other than

the Peregrines that most of us are interested in right now. I think it is quite obvious that through correllary experiments, knowledge that we gain from other birds of prey may help us in those that are in danger at the moment. From the Lincoln Park Zoo we have Mr. Robert Hinckley who will say a few words to us about the availability of birds in zoos and what the general attitude of people in zoos is as far as doing research in captivity breeding.

HINCKLEY. I'll speak about our zoo to begin with. We don't keep birds as singles at our zoo where it is physically possible to get mated pairs. We don't accept contributions of single birds at our zoo, we accept only mated pairs and we don't display single birds at our zoo. We display only mated pairs wherever it is physically possible to have them. That's our position.

We have outdoor flight cages for large birds. We have a pair of Golden Eagles that have laid eggs for two years and the male has copulated with the female for two years. These birds are on display and we have good hopes for this spring. We have a new pair of Bald Eagles and White-headed Eagles, certainly of breeding age. We have high hopes for them. We have a pair of Andean Condors both in adult plumage and they have nesting facilities available. We have a pair of Griffon Vultures with nesting facilities available. We have a pair of Verreaux's Eagle Owls with nesting facilities available.

The problems of displaying birds at zoos go into several categories. The first is, after all, we do have birds on display, and that is one of the primary functions of the zoo. One of the next problems with display is security. We can display Golden Eagles and we don't worry about people sneaking in overnight and stealing them. We don't have any doubt, however, that if we put a pair of Gyrfalcons on display in a breeding project that within a week they'd be stolen. So one of the very legitimate problems that any zoo has is that you cannot keep attractive, exotic birds of prey and expect to keep them, so we don't attempt to keep those kinds of birds. The next problem the zoo has is the expense of providing outdoor flight cages. There is no such thing as taking a few posts and some chicken wire and for 60 bucks putting up a display at a zoo. You have to get bids through the park district and then you have to have union people put the displays up and then you're talking about thousands of dollars just for cyclone fence. So it's not an easy project from that view. One of the major stumbling blocks without any question is knowledge and the competence about birds and this is a problem to which this group could readily address itself. Another one of the problems on setting up breeding pairs is the Fish and Wildlife people. We tried for three years unsuccessfully to get an immature male Bald Eagle to go with our immature female Bald Eagle and we still don't have one. There is no question that there is a good deal that Raptor Research Foundation could do to assist zoological parks. One would be some kind of information bulletin, just on the basics of getting your birds to breed. Some people don't realize it's wrong to keep several species in the same flight cage. A consultation committee might legitimately be set up through Raptor Research to assist zoos with breeding projects. It might be possible to set up some kind of breeding award for

zoos, since the public in general does not always recognize how much time and effort and endeavor on many people's part went into successful breeding in front of the public. It might be well to offer some kind of recognition to those people who have succeeded, such as the Topeka Zoo with Golden Eagles nesting this year.

HUNTER. Thank you very much, Bob. We have one more panelist who would like to say a few words, Bruce Wolhuter from the Cheyenne Mountain Zoo in Colorado Springs.

WOLHUTER. I think the other zoo people here really expect a rebuttal, but I have to agree with everything that's been said. In the zoos we are woefully ignorant, for one, on how to take care of birds, and two, as Thacker pointed out, some of them don't even know what the difference is between the raptors. Zoos basically have several problems; one is that for the most part, zoos are display oriented and they're more interested in displaying the birds, the largest number of birds, without thought to conditions or what they're putting in with what. And of course this is disastrous if you're trying to do any kind of breeding at all. I would say, well over 90% of zoos I'm familiar with have at least one or two exhibits where they have to have at least six or seven species put together. And I think most of you realize this pretty well precludes any chances of breeding. If you want to have birds that are breeding it's necessary, first of all to start out with a pair and some zoos don't know whether they have a pair or not. When I went to the Cheyenne Zoo (I started about a month ago), they had about six female Kestrels in a cage. Obviously it's going to be kind of a rough breeding project unless they can change their ways on that. And those are the birds that are easier to sex. So, you've got to get qualified people that can sex a bird to the point to know whether they have a pair or not. And then you have to isolate the birds, meaning not mixing them with other species. You have to set up conditions that will at least encourage breeding and a lot of zoos will fight this, depending on whether the zoo is run by the City Park Commission or by its own zoological society, but there is a need to get these breeding conditions set up. There's a question in my mind as to the value of removing these birds from public view during the breeding, whether this public contact is detrimental or not. It remains to be seen; some zoos have bred birds where the public has complete access. I know Topeka Zoo with their Golden Eagles, this particular year was the year that they didn't really do that much work with the eagles and the first thing they knew, they had eggs. As soon as they got the eggs they isolated the cage, whereas in the past they isolated the cage entirely all the way through as soon as the courtship activity was started. And something Bob mentioned, the problem in zoos of singles. So many zoos say well, if you've seen one you've seen them all; we'll just put one on display; it's too expensive to get more. I think this is one thing where the zoos can work together, by cooperation. Bob mentioned that they have a pair of Andean Condors and

there are several zoos who, just for example, have just one Andean Condor and I think it would be great if they could get together, you know, loaning birds, strictly for the purpose of breeding.

Let me just mention that the majority of zoos are not feeding the birds food that, in my mind, is even good for maintaining them in healthy condition, and it certainly isn't doing much to encourage breeding.

HUNTER. Thank you very much, Bruce. We will entertain a few questions from the floor now. We encourage participation as much as you would like. I think Joe has his hand up first back there.

PLATT. Yes, Mr. Thacker, the idea of tighter restrictions, has this gone through? As far as impounding birds?

THACKER. Yes, it went through, yes.

WOLHUTER. I want to make a comment—you're asking about the importation of birds. They're really tightening up controls; right now it's impossible. They're particularly watching the falconiforms and also the strigiforms and any more if you import a bird, first you have got to have papers from the country which it was imported from, saying it was taken legally. Otherwise, no soap. Also this has to be cleared with our government before you can bring them in. I've also seen a rough draft of legislation that's being prepared . . . something like the endangered bird, a group that's interested in this. And they're trying to tighten it up even further in such a way that there will be complete control. So I think the era of bringing birds in for pets is about over. What effect this will have on bringing birds in for breeding purposes or anything else remains to be seen. But it's going to get tougher and I think it's probably a good thing as far as getting rid of the commercialism.

THACKER. The other thing you have got to remember on importation of birds is as I understand it, when they're brought in and they're presented at the dock or wherever they're coming, in, the person who inspects that bird is not somebody who is oriented towards them, since he's a customs official, and if he doesn't have an interest in birds of prey he could be looking at a bantam chicken. Now this is serious. He has no idea what's coming in. If the guy tells him, well it's a red-footed fighting cock, he's going to put down on the paper a red-footed fighting cock in many cases. I've seen lots of these papers come through. But I do believe the bureau will be sending people down to instruct these customs people in the falconiforms and the strigiforms.

HINCKLEY. There is one more point here, there is today perhaps as much as 20% chance that some time in the next twelve months there will be a total ban on importing all avian species into the United States because of Newcastle's disease.

THOMAS. Roger, about what you just said. I can remember last year at the NAFA convention someone brought up the point that the federal people had five or six different stations around the country that all the birds of prey or anything like that that could remotely resemble it had to go through those stations and these people . . .

THACKER. They are on call . . . the customs people, as I understand it, if they get something they do not understand, they can get on the telephone and say, come down and take a look at it.

SCHUBERT. I have a point about what Mr. Hinckley was saying. I think Raptor Research should be more in touch with zoos. I used to work at a zoo. We oftentimes got raptors in that nobody wanted. We had too many Red-tails; we tried to trade them off with other zoos, but nobody wants Red-tails . . . just put into a cage until they die, or else overcrowded, 10 or 15 Red-tails in a cage. I think Raptor Research could be in touch with these zoos and with other zoos to provide more information service where they can send those they don't want Right now we have a Crane Hawk we don't want; if anyone here wants a Crane Hawk they can have it; they don't know what to do with it. They have a Krider's Hawk that isn't doing well in captivity, they want to send it out west. I think there definitely are lots of raptors in zoos.

HUNTER. Thank you very much. And as far as Raptor Research is concerned we'd be very happy to do this sort of thing and we would accept volunteers. Any more questions? I think maybe we've gone over this. We've got lots of very interesting ground to cover and unless there are any more questions we will close this and go on to the next panel.

RAPTOR RESEARCH

Volume 6 Supplement Part H 1972

SPECIAL CONFERENCE ON CAPTIVITY BREEDING OF RAPTORS—A REPORT

Sponsored by Raptor Research Foundation, Inc.
Held at Sioux Falls, South Dakota, U.S.A., November 21-23, 1971

Part H. Health and Nutrition of Young (Panel 10)

edited by
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Panel Members: Richard D. Porter, Chairman, William H. Halliwell, and David E. Allen; contribution of John Serafin was presented by R. D. Porter.

PORTER. Health and nutrition of young raptors or nestling raptors is a poorly known field of investigation. Although there is a considerable amount of information on the nutrient requirements of young chickens, there is not much known on this subject as regards young raptors.

Although Dr. John Serafin, the nutritionalist for the Rare and Endangered Program at Patuxent, was unable to attend, he authored the following discussion on nutrition of young poultry which has a degree of applicability to all young birds in process of rapid growth and development.

*PRINCIPLES OF NUTRITION, by John Serafin**

Nutrition is the process of assimilating food. The chemical reactions that cause the metabilic functions of the animal to occur are supplied with raw ma-

Nutrition is the process of assimilating food. The chemical reactions that cause the metabolic functions of the animal to occur are supplied with raw material from the environment, through processes lumped under the term "nutrition." This definition includes the ingestion, digestion and absorption of the chemical elements which make up food, and the distribution of these nutrients

*Patuxent Wildlife Research Center, U. S. Bureau of Sport Fisheries and Wildlife, Rare and Endangered Program.

within the animal organism in the proper form for use by the cells.

The complexity of the chemical substances that an animal must obtain from his environment varies widely throughout the animal kingdom. Some unicellular organisms have very simple nutritional needs, mainly some inorganic elements, a source of carbon and energy and a few nitrogen compounds. The bird has very complex nutritional needs with over forty specific compounds, classes of compounds, or specific elements required from the environment for the internal chemistry of this animal to function properly. Even this is a relatively simple list of raw materials from which to build the myriad of compounds present in the animal body.

Because of the economic importance of the chicken for food through the production of meat and eggs, much effort has been expended to determine adequately the nutritional needs of this animal. Because the young chick is an excellent experimental animal for fundamental nutritional studies, more information is available about the nutrition of the chicken than any other animal today. This reservoir of nutritional knowledge has placed the formulation of poultry feeds on a scientific basis and made possible scientific formulation of diets for other species of birds as well. Today feeds for many species of birds in zoos, birds captured from the wild and ornamental and show birds can be successfully reared using scientifically formulated diets.

Qualitative Nutritional Needs

These needs of birds can be divided into categories. These are:

1. *Sources of energy.* Many types of compounds can supply energy to birds but the primary energy sources are classes of compounds called fats and carbohydrates. Not all carbohydrates and fats can be digested by birds, so that only carbohydrates and fats that can be digested and absorbed by the digestive tract can be considered nutrients.

2. *Amino acids.* Proteins of the animal body are really polymers of some 22 amino acids that are arranged in an almost infinite variety of combinations to produce the specific proteins of the structural and enzymatic systems of the body. Some of these amino acids can be synthesized by the bird from simpler compounds, but others must be included in the diet of the bird.

3. *Vitamins.* This term encompasses a group of compounds widely differing in chemical structure. They are all required links in the chain of metabolic reactions that occurs in the animal body. The chief properties that set vitamins apart are the minute amounts in which they are required, and the types of metabolic functions they perform.

4. *Inorganic chemical elements.* Many individual chemical elements are required for proper metabolic functioning of the bird. Amounts required and functions of these elements vary tremendously from the large amounts of calcium required for bone structure and egg shells, to infinitesimal amounts of selenium required for presently unknown functions.

5. *Water and oxygen.* No description of the chemical relationship of an animal with its environment would be complete without mention of these two

very important components. Life is not possible without water and oxygen. Water forms the medium in which body chemistry functions and oxygen is required for the fire which releases energy from the foodstuff.

Quantitative Nutritional Needs

Although it is possible to define the qualitative nutritional needs of an animal in terms of individual chemical compounds, elements or classes of compounds, the quantitative nature of nutrition is not so simple. The amounts of a nutrient required in the diet depend on many factors. For example, the requirements for amino acids vary with the total amino acid content of the diet and also some amino acids specifically influence requirements of others. The saturated fatty acids content of the diet may influence the linoleic acid needs of the chick. Pantothenic acid and vitamin B_{12} requirements may vary with levels of each. The phosphorus content of diets, particularly for young, rapidly growing birds is dependent upon the calcium level in the feed and excesses or deficient amounts of one or the other can bring about severe skeletal deformities. As a percentage of the diet, most nutrient requirements vary with energy level. Chickens tend to regulate feed intake to a certain caloric consumption. From available evidence this seems to hold for other species as well. In high energy diets less feed is required to meet the energy needs than in diets with low energy concentration. Therefore a specific daily intake of a protein requires less protein as a percentage of the diet with a low energy concentration than with a higher energy concentration.

Ideally there is undoubtedly a specific quantitative combination of amino acids to give the most efficient conversion of dietary protein to body protein or egg protein. There is a specific relationship between amino acid levels, fat levels and carbohydrate levels to give maximum utilization of dietary energy for productive purposes with a minimum loss of heat.

Palatability and nutritional adequacy also are interrelated. Palatability is a rather ill-defined term that usually means that consumption of a given diet or substance by a bird is affected by taste, physical factors, and any other term usually felt to be unrelated to the nutritional addquacy of the diet. Through the years, increased research has shown that nutritional adequacy of a diet influences voluntary feed consumption far more than certain vaguely defined palatability factors. Diets in which pure amino acids supplied the protein needs of the chick used to be considered "unpalatable" for chicks because chicks would only consume small amounts of these diets. However, as research discovered better combinations of these amino acids, feed consumption improved. A diet with good quantitative balance between nutrients present is in most cases also a highly "palatable" one, that will be consumed readily in large amounts.

Supplying Nutrients

Nutrients can be supplied to birds in several ways. It is possible to produce pure forms of nearly all the nutrients required and to make diets using these

Table 1. The Nutrient Requirements of Chicks (0-8 weeks of age).

Nutrient	Amount required in diet
Metabolizable energy, Cal/kg diet	3000-3650
Protein (N x 6.25), 0-4 weeks	22%-28%
Protein (N x 6.25), 4-8 weeks	20%-24%
ME/P (ME Cal/gm protein), 0-4 weeks	13.2-13.5
ME/P, 4-8 weeks	15.0-15.3
Amino acids:	Percent of the protein
Arginine	6.0
Lysine	5.0
Methionine	3.5
or Methionine	2.0
+ Cystine	1.5
Tryptophan	1.0
Glycine	5.0
Histidine	2.0
Leucine	7.0
Isoleucine	4.0
Phenylalanine	7.0
or Phenylalanine	3.5
+ Tyrosine	3.5
Threonine	3.5
Valine	5.0
Fat	+
Linoleic acid	2.0
Fiber	
Minerals:*	Percent
Calcium	1.0
Phosphorus	0.6
Available phosphorus	0.45
Sodium	0.25
Potassium	0.3
Chlorine	0.15
Magnesium	0.05 (500 mg/kg)
Manganese	0.005 (50 mg/kg)
Zinc	0.005 (50 mg/kg)
Iron	0.0025 (25 mg/kg)
Copper	0.0003 (3 mg/kg)
Molybdenum	0.0002 (2 mg/kg)
Selenium	0.00001 (0.1 mg/kg)
Iodine	0.000035 (0.35 mg/kg)
Cobalt (required only as part of the vitamin B_{12} molecule)	
Sulfur (requirement supplied in form of methionine and cystine; also present in thiamine and biotin)	

Nutrient	Amount required in diet
Vitamins:*	
Vitamin A (stabilized)	1320 IU/kg
Vitamin D_3	550 ICU/kg
Vitamin E (acetate is more stable than alcohol)	15 IU/kg
Vitamin K_1 (menadione sodium bisulfite—Vitamin K_3—approximately same requirement)	0.8 mg/kg
Thiamine (Vitamin B_1)	1 mg/kg
Riboflavin (Vitamin B_2)	4 mg/kg
Pantothenic acid	13 mg/kg
Niacin	33 mg/kg
Pyridoxine (Vitamin B_6)	4 mg/kg
Biotin	0.12 mg/kg
Folic acid (Folacin)	0.60 mg/kg
Vitamin B_{12} (Cobalamin)	0.01 mg/kg
Choline	1200 mg/kg
Ascorbic acid (Vitamin C)	Not required
p-Amino benzoic acid	Not required
i-Inositol	Not required
Thioctic acid	Not required
Mevalonic acid	Not required

*Mineral and vitamin requirements as given apply to diet containing 3000 Cal ME/kg. Requirements increase in proportion as energy content of diet is increased. (For example, at 3650 Cal/kg of diet, available phosphorus requirement is 3650/3000 x 0.45 = 0.55%.

Possible unidentified required nutrients:

1. Water-soluble-organic
   (a) Spares zinc requirement
2. Water-soluble
   (a) contains selenium
3. Fat-soluble
   (a) Present in vegetable fats, egg yolk fat and lard
4. Water-soluble
   (a) Present in intact proteins

[1]The "requirements" presented here are based upon interpretation of research evidence to date. Undoubtedly, they do not represent the optimum "balance" of nutrients. Further research on interrelationships between the various nutrients will lead to changes in the "required" levels of many of these nutrients.

pure nutrients. This is the method commonly used to study qualitative nutritional requirements. Vitamins and essential elements were discovered as diets of increasing purity were found to be deficient in factors present in impure ingredients.

Ordinarily, however, nutrient requirements of birds are met by making use of plant materials or animal by-products, mineral elements, along with some chemically synthesized vitamins, and amino acids. Many sources of various nutrients are available for use in bird feeds. Where it is possible to supply a vitamin such as riboflavin more economically through chemical synthesis rather than by milk products, for example, this then is the method ordinarily used.

Feed ingredients vary in their ability to supply nutrients required by birds. The amino acid composition of fish meal, for example, is closer to the needs of the chicken than the amino acid composition of peanut meal. Corn is a far better energy source than wheat bran. Niacin is poorly available in grains but is supplied readily in pure form or by yeasts. Feed ingredients differ markedly in their ability to meet nutritional needs of the bird because of their composition, digestibility, presence of toxic materials and many other factors. Part of the problem of applying scientific nutritional information is the evaluation of available feed ingredients, and their ability to supply the nutrients required. Table 1 lists the nutrients required by birds and gives the approximate amounts needed in the diets of chicks to support satisfactory growth. While the table happens to show the quantitative requirements for the chicks, it is possible to formulate for many species using these values as guidelines. Requirements between species vary only slightly in basic nutrient needs and while the form these nutrients are ingested in may vary greatly in some instances, the basic nutrients and amounts remain much the same. Thus diets can be formulated for almost all species of birds using ingredients which will supply ample amounts of these nutrients to support growth, well-being, and reproduction. By considering the nutrient composition of ingredients and blending those ingredients which are acceptable and will be consumed by a bird, one can provide wholesome, complete diets for nearly any species, be it a quail, chicken, goose or eagle.

A. DIGESTIVE TRACT BLOCKAGE BY FECALITHS

PORTER. We fed our captive American Kestrels chicken parts and whole ground rodents. Even though the diet seemed to be very adequate for the growth and development of young Kestrels, we ran into a problem in 1967 involving four out of about 130 young. The fur that was present in the food accumulated in their stomachs and they were unable to form castings so as to regurgitate it. As a result, fur blocked their digestive tract and they apparently starved to death. This affected only the very young nestlings. This was a very low mortality rate, involving only a small percentage of the young. The following year this kind of mortality was not evident.

HALLIWELL. A Golden Eagle at the Topeka Zoo at six or eight weeks of age

died due to a fecalith made up of undigestible materials of fur, feathers and bone. These materials reformed into a hard calcareous mass and obstructed the intestinal tract. This same problem has been encountered in other young birds and seems to be reasonably prevalent. At the time the eaglets were hatched at the Topeka Zoo they were removed from ZuPreem and placed on rabbits and rats. In eagle nests visited in Colorado, Wyoming and Montana, there were considerable numbers of rabbits and some young foxes and coyotes. The percentages of fur, bone, teeth and other indigestible parts in the eagles' natural prey is about 30 percent of the total. Is there more parenchymous organs and less bone and fur in these prey species which would make them more digestible to the eaglets and thus eliminate the fecalith problem?

SCHUBERT. A zoo [name not given] that received an immature Bald Eagle from an animal dealer subsequently seemed to get the cramps and died. An autopsy revealed a ball of "Stay-dry" (a commercial preparation to put on the bottom of the cage), all balled up in its digestive tract.

OLENDORFF. Golden Eagles do the same thing; a bird that had an amputated leg and constantly was eating off the floor had a ball of Stay-dry two-thirds of the way down the intestine. Stay-dry is dried sugar cane; pieces of sugar cane passed all the way through the intestine; I guess one stuck and they kept clinging, even though the eagles were casting up a great deal in proportion.

WOLHUTER. Birds have a tendency to find their own castings, if they are not fed food containing casting material; if the bird is fed on the fist and given plenty of castings, there is no reason for it to pick them up from the floor.

B. NESTLINGS AND CASTINGS

1. Captive Birds

HUNTER. A captive jerkin picked off the pieces of chicken having feathers and ate them himself and fed the young only parts having no casting or bone.

OLENDORFF. Young captive buteos (hand fed) started casting when they were six to seven days old; they were given bone when they were three to five days old. Their diet was ground very finely and consisted of three pounds of mice, three pounds of pigeon, three pounds of jack rabbit and three pounds of cottontail. Vertebrae, bones and skull bones of sparrows were fed to them very early after hatching. The bones were taken very readily by the young hawks. Cracking of the bones seemed to stimulate the feeding response.

FYFE. The captive Peregrines were fed Coturnix quail. The male would pluck the bird surprisingly clean and usually in plucking he would eat the head. He would then take the prey to the nest or to the female; there wouldn't be a great

deal of castings at that time. With the captive birds there was very little casting going into the nest from the very beginning other than perhaps bones which would be in the food itself.

HAMERSTROM. Young Red-tails seem to get their castings as soon as they start to care for themselves.

2. Wild Birds

TEMPLE. Yukon River Peregrines plucked their prey species up to a week before fledging, but they obviously had some castings before this.

GALICZ. Peregrines, observed from a blind in the Queen Charlottes some 10 years ago, did not appear to be feeding any casting material, only small pieces of lean meat.

C. TYPES OF FOOD GIVEN NESTLINGS IN THE WILD

HALLIWELL. During the initial period after hatching, hawks seem to feed their young quite a bit on the innards, particularly liver of the prey species: the liver seems to have quite a laxative effect.

HUNTER. When my jerkin came to the liver he made sure that the young got it; even when he was feeding away from the other birds and they were full, he would take the liver and feed it to them. The liver seems to have some special significance. Color had something to do with choice of food for the young: month old chicks have very light colored meat. The jerkin seemed to be avid when pigeons were fed and fed on all parts except the skin, whereas with the chickens he ate the bony structures.

GALICZ. My observations from a blind some 10 years ago with Peregrines on Queen Charlottes seem to support those of Hunter's. Peregrines were feeding the inner parts of Merlins to their very small young.

TEMPLE. Yukon Peregrines definitely fed their young a combination of muscle meat and viscera; on some larger shorebirds and ducks they definitely were feeding on breast muscle.

ENDERSON. A distinct impression from a frame (on a feeding sequence with Peregrines–time lapse photography in the Arctic) suggested that when the young were given small unidentifiable passerines the (adult) bird worked right down through the lungs, everything.

FYFE. Young, not quite a week old (Prairie Falcons), were getting mostly muscle meat from ground squirrels and birds at about four days of age. Captive

Peregrines fed young breast meat, possibly bits of liver, no entrails.

NELSON. On coast Peregrines–when the young were a very young age, their parents fed them breast muscle, and during the first couple of weeks the parents were extremely meticulous about not letting the young have any of the guts; they would offer the entrails to the young, then take them back, eat maybe 15 inches of the intestine, then resume feeding. Innards apparently were not fed the young at the beginning; it was almost entirely breast muscle–normally skinned, fairly well intact.

[Editorial Note: Figure 1 is a photograph I took at a Utah Peregrine eyrie in 1947 showing a youngster being fed entrails. R.D.P.]

HAMERSTROM. The subject of raptor baby food has been approached from several standpoints. Again I try to imitate what the parents would do. The raptors that I have watched closely by sharing the nest as a mate–Red-tailed Hawks and Golden Eagle–tend to feed liver, heart, lungs, and kidneys–but not intestines–of birds and mammals to small chicks. They fed some muscle even in the first few days after the hatch–especially that of young birds or mammals. Dr. Heinz Meng mentioned a preference for feeding dark meat to young chicks and,

Figure 1. Peregrines at 1947 Utah eyrie feeding entrails to young. Photograph by Richard D. Porter.

as I think back, I agree. It seems to me that pigeon breast was fed before rabbit meat by both species.

My female Golden Eagle partially swallows and then "regurgitates" morsels to small chicks. My male Red-tailed Hawk and Dr. Meng's female Red-tailed Hawk do not regurgitate, but feed tidbits well moistened with saliva.

I feed any very young raptor that I hand rear the above diet and both moisten and warm each morsel in my mouth before giving it to the chick.

[More information is available in F. Hamerstrom, 1970, "An Eagle to the Sky," Ames, Iowa: Iowa State University Press, and F. and F. Hamerstrom, 1971, Potential eines männlichen Greifvogels (*Buteo jamaicensis*) in Bezug auf Nestbau, Brüten und Jungenaufzucht, *Die Vogelwarte* 26:192-197; English translation in *Raptor Research* 6(4):144-149, 1972.]

SIMONYI. In the wild the adult birds (Peregrines) never give feathers to the young ones, but after about four weeks the young begin playing with the leftovers at which time some feathers are eaten.

FYFE. Regarding early feeding, two things that were very obvious both in wild and in captive Peregrines was the extent to which the adults cleaned the prey before they take it to the nest. The general pattern was that the male would return to the young with the head removed from the prey.

TEMPLE. Peregrines on the Yukon plucked their prey so thoroughly that it was difficult to identify the prey items brought into the nest, indicating only a remote chance for the young to be given extraneous casting materials in large quantities.

OLENDORFF. Red-tails, Swainson's and Ferruginous Hawks get pieces of fur and pieces of bone from the very beginning.

STODDART. About two years ago a Swainson's Hawk and a Prairie Falcon were given pine shavings for castings without apparent problems. The shavings formed good castings and appeared to cast up normally.

FYFE. Young, not quite a week old [Prairie Falcons] were getting mostly muscle meat from ground squirrels and birds at about four days. Captive Peregrines fed young breast meat, possibly bits of liver, no entrails.

D. DISEASE, PATHOLOGY AND OTHER HEALTH FACTORS

1. Rickets

HALLIWELL. In rickets, legs are bowed and feet turn in excessively; caused by feeding nothing but muscle meat.

2. Miscellaneous

OLENDORFF. Referred to a paper by Andre Brosset, which he translated from French (*J. N. Amer. Falconers' Assn.* 6:38-42, 1967). Brosset raised his young raptors on the floor because he experienced a bird falling off the table.

3. Frounce (Trichomoniasis)

OLENDORFF. Two young Red-tailed Hawks, age about 20 days, contracted frounce. They were treated with "Emtril" and recovered without any problems.

HALLIWELL. Description of Frounce: it's caused by a very small flagellated protozoan. Must be placed under a microscope to be seen. It causes a lesion in the mouth which is a result of the lining of the mouth being irritated. It forms a cheesy-like growth there. Following treatment it would probably take a day or two for the lesions to drop off.

To diagnose trichomoniasis: with a well-moistened Q-tip, swab the bird's mouth, particularly the back throat region. Put it in a drop of water on a microscope slide. An examination under the microscope will reveal millions of rapidly moving organisms. After treatment you should not see trichomonads after 24 hours, although you may still have scales.

HALLIWELL. I have never seen a case of Frounce that has been refractory to Emtril. One treatment of Emtril is literally a "sure cure" for trichomoniasis and it works superfast.

McINTYRE. I agree with Dr. Halliwell with but one exception: a Prairie Falcon in Denver that was treated twice, skipped a 24-hour period with three tablets of Emtril, one of each dosage and still had evidence of Frounce. He was then placed on Enheptin and this got rid of it. Why did the Emtril not work? One can not give it to the bird in the first bite of food because it goes past the crop, where it is needed and on to the stomach. To administer, take the bird's bill, close its throat, and poke the food into the esophagus and down into the crop. I do not worry about the size of dose.

HALLIWELL. Emtril comes in two forms—one is powdered and the other is a tablet. The tablet contains 125 mg. I use 125 mg/2 lbs of bird. Best to use powdered form, which you have to place in a gelatin capsule; however, may have problem with gelatin capsule dissolving in quickly enough to release the drug while the medicant is still in the crop where it will do some good.

Cattle which were given one or two tablets every day, on post mortem, contained 3-5 tablets; hence some tablets were in the digestive tract 24-48 hours. There is need to develop a better method of administration of medicant since either form is a problem.

LAYMAN. I use a catheter tube (orally) to administer drugs and liquid foods

to a Prairie Falcon.

SHERROD. When my Prairie Falcon got Frounce, I gave her one-third of a tablet of Emtril, but after three days the falcon still had Frounce. I then gave her an additional third of a tablet. This seemed to have adverse effects on the falcon causing her to go crazy.

HALLIWELL. Dosage (35-40 mg) given the Prairie Falcon was too low; treat with the entire 125 mg of the drug. However, indiscriminate use of the drug as a cure-all for everything is not wise.

RAPTOR RESEARCH

Volume 6 Supplement Part I 1972

SPECIAL CONFERENCE ON CAPTIVITY BREEDING OF RAPTORS—A REPORT

Sponsored by Raptor Research Foundation, Inc.
Held at Sioux Falls, South Dakota, U.S.A., November 21-23, 1971

Part I. Photoperiod Problems and Management (Panel 4)

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Vermillion, South Dakota 57069

Panel Members: Stanley Temple, Chairman

TEMPLE. Photoperiod is one type of external stimulus that we are definitely able to manipulate, something that we have under our control when we put the bird in a captive situation. This subject is going to be particularly critical with the falcons, since different populations nest at different latitudes. I might start out by telling you how birds evolved a photoperiodic or light induced control or timing mechanism for their reproductive cycle. There are several requirements that they would probably want in terms of what function they would use. One, it must be something that is easily perceived by the animal. Another thing, it must be something fairly constant from year to year, it shouldn't be changing drastically. Probably another thing is that it should be something that would vary geographically, so that the birds can adapt themselves to a specific geographic region; I think it doesn't take much to see that the varying daylight length throughout the year fits all these requirements admirably. It doesn't vary from year to year. March first is the same period of daylight from one year to the next. Light is something that is very easily perceived by a bird—birds are primarily visually oriented animals. Also it is something that varies quite a bit geographically, particularly with latitude. You all know that if you go north, you are going to have longer days proportionately during the summer breeding season of most birds. So, as Peregrine Falcons—we might as well address ourselves to Peregrine Falcons right off—as Peregrine Falcons evolved in the tundra ecosystem they had to adapt their endocrine system specifically so they

were using the light regime, the photoperiod, that is present in the tundra. They are specifically adapting themselves for that condition.

I think, very simply, you don't have to get anything very complicated, on what kind of light regime to put a bird on in terms of light and dark. You can pretty much point blank say that. You should try to duplicate as closely as possible the light conditions of the latitude of the region from which the bird came. For tundra birds this means that during the breeding season you should have them on long periods of light, probably 20 hours of light a day is going to be necessary. For birds such as Peale's Falcon or an *anatum* type of Peregrine, if you keep them at the latitude where they were normally taken or fairly close to it, there is no need to supplement with artificial light. I think that it is abundantly clear from the success with Peale's Falcons and Jim Enderson's *anatums.* Natural light is perfectly adequate unless you have a closed breeding chamber. For tundra birds, and I suppose this is where most of our potential breeders are probably going to come from since that is the only viable continental race of Peregrines left, you are going to have to go to supplemental light in your breeding chamber.

What do we know about the type of light that should be given artificially? There are a couple of things that are definitely known about a bird's receptiveness to different types of light. This has been shown conclusively in studies of photoperiodicity on many species of passerine birds; not much has been done with birds of prey. But all of the other kinds of birds that have been looked at once again show this uniformity—they are all pretty much the same in their adaptation to photoperiod. One thing that comes up right away is the intensity of the light. Every experiment that has been done to measure the intensity of light that is necessary to trigger a photoperiodic response in a bird shows that there is a threshold level above which more intensity does nothing to increase the photoperiodic response. In other words, if you get the light to a certain level, more light is **not** going to strengthen the photoperiodic response. The threshold level that has been discovered in such birds as House Sparrows, finches, Starlings, is quite low, below what I've seen at most breeding facilities. Just take a regular camera light meter; you can approximate the light that you would get from daylight with your photofloods. Take a light meter reading off the floor; if you can duplicate the intensity with photofloods, you are in fine shape as far as intensity of light goes. There is no evidence to suggest that brighter intensity is going to help you out. The other thing that is probably critical is the color or the colorimetric spectrum or character of the light. The spectral quality of artificial light will vary from light source to light source. They have done quite a few experiments once again on different species of birds to find out which wave lengths are most stimulating to the gonads. And I don't know whether you want to call it a night club effect or something—red light is the most stimulatory. If you submit a bird to light that is rich or has a high red wave length to it you are more likely to get a stimulatory response from the bird. Blue light, light that tends toward the ultraviolet, is the worst that you can use. Infrared light is not effective, it's invisible and the things that are stimulatory are in the visible spectrum.

birds, should be putting their birds onto two summers a year. And they may well get in one of these summers production, as it is. Now they're not even getting eggs with just one exception over here.

TEMPLE. Well, if you're going to assume a transequatorial migrant, then you are going to put the bird on essentially two summers. And if you suspect that, then what I mentioned earlier about this photorefractory period is protecting the bird from the second cycle. I would be very surprised if you could recycle that tundra Peregrine. Not until a year later. I'm almost certain.

GRIER. Dr. Porter, have your American Kestrel populations from different areas shown the same thing? You've got different times under the same regime with the breeding.

PORTER. Right, we, in our colony, have Kestrels that were obtained as nestlings from Massachusetts, New York, Ohio, Pennsylvania, and Maryland. We also had a group of Kestrels, female Kestrels from Florida, that were obtained in the winter. The weights of the Florida Kestrels from Florida were not significantly different from those from the northeast which suggests that they're probably not of the small Florida race, the resident race. In any event the Florida Kestrels nested a month later than did the birds from the northeast. They maintained this despite the fact that they were right in the middle—even the Florida Kestrels that were placed right in the middle of the colony with the birds from the northeast, still maintained this month's difference in nesting data, a month later. However, as we looked over our records, there was a tendency for this gap to decrease slowly each year. We really need some experiments with the Kestrels to determine what they're actually behind in.

TEMPLE. I think it's a little bit too much to hope that all tundra birds will quickly adapt, you know, in a matter of several years.

HUNTER. Would you think then that maybe just a total increase in light suddenly would be as good as a gradient?

WHITE. That probably may not be the answer.

HUNTER. What I'm getting to is, is a sudden increase in the total light equally as good as a gradient increase?

TEMPLE. Once again if we're safe in extrapolating from other species there doesn't seem to be any advantage to giving the birds graded increase in light. For most species the sudden jump up to a stimulatory photoperiod is sufficient, unless raptors are very different from the other birds who have been examined; there's no reason to think that. If you're going to bring this on your tundra birds at the appropriate time, sometimes perhaps during May, up into 20 hours, I would think that would be perfectly adequate to do it in one increase.

HUNTER. Some chicken people do this though. They bring the light up slowly, graded, to increase productivity.

WOLHUTER. I'm wondering if there's a difference between just all of a sudden throwing a long photoperiod, versus gradual, when you talk about the threshold, the bird reaching a threshold, is there any difference in that? Also would that differ with some birds, like our transequatorial migrants?

TEMPLE. I can't say that we know for sure with birds of prey, but with other birds that are easier to breed in captivity, the sudden increase in duration is sufficient.

WOLHUTER. There's no need to build up—you can start them long?

TEMPLE. No, so it is with other birds. I'm not saying it's the same as raptors, but seemingly we can apply information from other birds to raptors, just as well.

GRIER. We can't say that poultry takes a 14-hour day and all you have to do is put them at that and hold them at that and they'll keep producing.

MOLT PROBLEMS

HUNTER. I have another comment I would like to make. Something on the order of seven or eight years ago, I put Dakota Belle, a tundra Peregrine, on 24-hour light on January 1; 43 days later she began to molt. The next year I did exactly the same thing but I waited one month later until February 1; 44 days later she dropped her first feathers with the full light, 24 hours. Then the next year I gave her no light; she dropped her feathers as she always had before, on the 12th of July. Now we're only assuming that there is some tie-up between molt and reproductive activity, but . . .

TEMPLE. Yes, the correlation between reproduction and molting, photoperiod molt, is probably just a sort of a spurious correlation. It's pretty clearly shown that the thyroid is probably the organ that is most directly related to inducing molt. And it is being stimulated by photoperiod, you're right, but the stimulation is going to the hypothalamus and it's releasing another hormone that has little effect on the gonads; this is the thyroid stimulating hormone which stimulates the thyroid in the same way that the gonadotropins stimulate the gonads.

HUNTER. On the questionnaires, one of the things I left out I am afraid was a question of when the first feathers dropped in molt; now I do have some of these data from various people, many of them having observed the first feathers to be dropped in the molt after the second egg was laid in the first clutch.

MARCUS. I'm a little confused about all this conversation about total exposure and total light, integrated light exposure versus light periods. I think we're getting mixed up about how many Langleys, for example, does a bird get exposed to? All this seems to be affected by weather and it seems like an unusual condition in which it would be clear short days that would stimulate, perhaps help stimulate activity. Then you'd have all kinds of false starts possibly.

TEMPLE. Remember what I said, there is a threshold level above which more intensity doesn't stimulate the bird any more strongly, you know.

MARCUS. Energy, you have to measure the light energy. The temporal light has to do something, it has to cause, let's say, a photochemical reaction and so it has to be a total energy quantum, or something that . . .

TEMPLE. No, that's exactly what these experiments disproved, that there is not a direct correlation between intensity of light and response. There is none. In other words, you don't get it below a threshold; as soon as you reach that threshold, you get that response.

MARCUS. I'm just disturbed about this business of length of period versus total exposure. I just plain cannot get the question out of my mind.

TEMPLE. In order to explain why transequatorial migrants ever leave South America, there is an hypothesis that it is the total exposure to light on the wintering ground that triggers them to leave. I don't see how this would work on stimulating the gonad in light of what we know with other birds.

GRIER. I think what you're saying is whatever it is, the total amount of radiation isn't as constant as what you were saying initially was necessary from an evolutionary sense. Let's say the day length is going to be the same thing from year to year on the 15th of May. The amount of light can depend on fog or cloud cover and all that.

MARCUS. But you have to measure the exposure in some way. It's not a timed period and how are you going to measure total exposure time? You have to integrate it in some way.

TEMPLE. In other words you're saying that two days out of two days and a foggy day is worth one day in a sunny day.

MARCUS. I'm not saying that's so. I'm saying it doesn't make sense that way.

TEMPLE. No, it doesn't. I agree.

HUNTER. What about the problem of light intensity for threshold?

TEMPLE. I don't think that is a problem, Don. I think all the breeding chambers I have seen or heard of are sufficiently bright.

HUNTER. One thing that bothers me is that it was said by someone and I got the impression that we need the approximate light outdoors inside the building; a little bit difficult.

TEMPLE. The evidence from sparrows and other species indicates no.

HUNTER. It might be helpful—I would like to suggest this—it might be helpful if we take candlepower which we can do with a regular photographic light meter. If anyone could do this and take light meter readings, it may be of some value.

TEMPLE. Certainly as bright as possible.

CAMPBELL. Don, I went into this quite extensively, not being much of a photographer. I went into this with the poultry peopld; the intensity of artificial light comparable to daylight is four watts per square foot of floor area. I also went into this in the schools and the same principle applies in the schools, your overhead lights or movable, I think, is four watts per square foot, this is what I am told.

HUNTER. At what distance from the light would this be? It seems there would have to be a distance factor.

CAMPBELL. No, I don't think so; if you put your light meter on the ground. In my own case each breeding chamber has roughly 145 square feet, 12 by 12, so I can put 600 watts, equally distributed in that pen.

SIMONYI. May I say something, since for the past four years I have had Redtails and the past two years, Peregrines. They need from 95 to 110 candle foot power, per square foot, and that's it, nothing else.

HALLIWELL. And you run yours 13½ hours a day?

SIMONYI. Well, I start off at nine and from there I work it up; you can go as high as you want, up to maybe 20 hours.

THACKER. You were talking about colored lights, reds and blues. Four years ago in Europe there was some work done by Manhölds, mostly on lab mice and rats. If they were exposed to different colored lights, you could almost tell what sex the offspring would be. The various colored lights would produce various sexes, like blues would produce one sex, reds would produce another.

TEMPLE. I know that experiment; a lot of people were very skeptical about the results. It's the type of thing where your sample sizes weren't large enough,

there's a possibility those were spurious.

THACKER. Well, I think he repeated them after he did them the first time, because there were so many people that were doubtful.

STODDART. I understand that for mammals to reach puberty they have to have so many hours of infra-red.

TEMPLE. I'm not really up on the mammalian literature, but as far as I know, that is still pretty much a theory.

GEOGRAPHIC PROBLEMS

GALICZ. Just for a point of information on our birds in British Columbia that did lay late in the fall, there was no artificial light used, both last year and this year.

TEMPLE. This is a phenomenon that is sometimes seen in many species and it's very difficult to explain, especially in male birds. You often do see some type of sexual activity in the fall and the reason for this isn't clear—some species even increase their gonadal size.

GALICZ. These birds are very sexy, they produced fertile eggs.

TEMPLE. That's very interesting.

MENG. Stan, in this whole regard I have a feeling that if we have tundra birds, eyasses, that are four years old, they'll probably react like four year old Peale's. I don't think there have been any that have been kept for four years, are there any?

FYFE. I have an eyass female and the eyass male will be three next year. But the female is eight, and she was raised as an eyass.

TEMPLE. We have six year olds, Alaskan birds at Cornell. This is one thing I'd want to clarify right off the bat. A bird will probably not adapt to a different photoperiod from that of the population it is taken from. The experiments here were taken from White-crowned Sparrows which breed, as you know, from California right on up to Alaska and they were not able to stimulate White-crowned Sparrows from Alaska to the summer photoperiod in California.

WHITE. I'd like to make a couple of comments here that I would hope may be germaine at this time, because I think a lot of us think photoperiod is really not understood and we'd hope that those of you working especially with birds of tundra origin would take very good notes on what happens to your birds and the way in which they respond. As Stan mentioned, there are often double cycles. Ptarmigans are a good example of birds that in September set up terri-

tory for about a week. This may be what happened in British Columbia with these resident birds. Secondly, as Stan also mentioned, when you have trans-equatorial migrants, we don't really know what it is that triggers off the return of migration. For example, there are voluminous data to demonstrate that birds from tundra origin moving north in the spring as in April and May across breeding grounds of birds that are already breeding. Many of these birds do not have developed gonads, and when they arrive in the tundra, many of them still do not have developed gonads. And so one would suggest that rather than the hour photoperiod, say a 16-hour photoperiod, or whatever, but rather it is the total accumulation of light over a given period that causes gonadal cycling. So with these long-distance migrants I would hope that those who are working with them would take very, very good notes on what they do in terms of this because the same phenomenon has been noted in birds of the Soviet Union in birds here.

NELSON. On these arctic birds would you care to speculate as to the time ranging on them. I'm thinking particularly of Bob Berry's notes in one of the BPIE reports in which he said the birds started getting hepped up in the fall. Now as I see it, if the tundra birds are down in South America, something is getting them to move back north; this may be why the tundra Peregrine stimulated with hormones over here was exercising so much. Maybe she was trying to migrate back north as Richard Fyfe's captives apparently tried doing a few years back. The transition between South America and the Canadian Arctic, let's say, is going from an autumn to a spring and summer very rapidly. Now would you care to speculate on what type of a light regime people should be using in their captive building and how they might stimulate the birds as they would be stimulated in the wild.

TEMPLE. As I say you can do probably no better than to approximate the natural condition. I would probably put the birds onto a stimulatory photoperiod. For a tundra Peregrine, probably sometime around the first of May, the end of April. I would suggest something on the order of 20 hours of light, four hours of darkness. I would probably hold the birds on that light until probably late July or August and then drop them down to a winter photoperiod, perhaps drop them down to the normal photoperiod for the area where they were.

NELSON. That's the problem. I think that's what everybody has been trying to do. They give them one summer and then put them back into a winter which the birds never ever have seen.

TEMPLE. That's not true, because tundra birds, some of them, are transequatorial where they do go down there, but they certainly do winter on the Texas coast and Mexico.

NELSON. Yes, but we don't know where those birds are coming from necessarily. My point is that these people, at least some of them with high arctic

Now how do you stand when you start using incandescent bulbs or fluorescent light? You're actually in pretty good shape on both of these. They both tend to produce light of a wave length that will give you a good red component. And actually I can't think that you can improve very much on normal indandescent and fluorescent light. They're both very adequate. There are some that may be better. You may be familiar with light called Vita-light. It is a fluorescent bulb that has specially tinted glass and very closely approximates the natural spectral composition of daylight. If you want to do it naturally, one of these Vita-lights is probably one of the best things you can get for it. We've got a couple of other considerations . . .

CRAWFORD. Is that the same as Gro-light?

TEMPLE. Gro-light, yes, the same thing. It's a different product name. Any of these, there are several brand names, but these are ones that are filtered so they approximate a natural spectrum. You're basically pretty safe with just about any of the artificial light sources.

One other thing that you have to worry about is the phenomenon that's been called the refractory period. Let's just follow a Peregrine, she's migrating up to the tundra, increasing her photoperiod, the daylight per day stimulating her gonads, she reaches a point at the end of the breeding season where her gonads start to regress. As her gonads start to regress, she enters a photorefractory period. This photorefractory period varies from species to species in how long it is, how long it lasts. During this period further increases in the photoperiod will not stimulate gonadal growth. This is very adaptive; consider what happens to that tundra Peregrine when she leaves the arctic in late summer. There is a decrease in photoperiod; by heading south, she crosses the equator, going down to Argentina or wherever she might want to winter. Once she crosses the equator, she's in the Southern Hemisphere and she starts increasing her photoperiod again. It's obviously nonadaptive to have gonads enlarging on the winter grounds. And this photorefractory period, you can almost assuredly say, in a species like the Peregrine Falcon where they're known to be transequatorial migrants, is probably quite long, It probably takes them on through to early winter, probably mid-winter, on the order of four or five months.

Now what does this mean in terms of recycling your bird? We haven't really discussed this at all, but it's something that really bears consideration. Using the photoperiod and artificially manipulating the photoperiod, it is possible to put your bird on more than one stimulatory light cycle a year. There have been a number of people who've tried this; I think Jim Enderson has been the most successful in getting some reproductive behavior from his Prairie Falcon by giving it a stimulatory light regime in the late fall. This is fine for a Prairie Falcon. The Prairie Falcons, since they aren't highly migratory, probably have a very short photorefractory period. I would definitely say that it's not going to be possible with tundra falcons to get them to recycle, to go through more than one breeding cycle in a given calendar year because of this photorefractory period. It may be very different with Peale's Falcons and I understand the group

in British Columbia has some evidence that they are able to recycle their Peale's Falcons so they can get an extra reproductive cycle in the fall. Now the way you would accomplish this if you're going to do it by artificially manipulating the light, would be to allow your bird perhaps in the spring to follow a normal stimulatory photoperiod, once she had finished a reproductive cycle, drop the lights down to a nonstimulatory or winter photoperiod, keep the bird on that. I would probably say extend that period; without any basis for how long, you should extend it, but for most species I would imagine you should probably extend it for a good three or four months, I would say 90 days at least, before you started increasing the birds' photoperiod again, to restimulate. This way I think by careful manipulation you should be able to get more than one clutch out of a bird a year. I think it hasn't been said so far, but I think you're probably all aware that in falcons in particular you can remove a first clutch of eggs and they will replace with a second and sometimes a third clutch. Once again if you've got a Peregrine that will produce fertile eggs, you can probably get 25 Peregrine eggs out of two Peregrines by constantly causing them to recycle, as Jim Enderson has shown very clearly, even though these were infertile. I think that's probably about it for photoperiod. It's really fairly simple. There's no mystique about it.

LIGHT–QUANTITY AND QUALITY

LAWSON. I think there have been some experiments done in poultry where they actually put discs in the eyes of the birds and they claim that the light stimulus actually goes through the skull.

TEMPLE. This is serious controversial work. I might summarize that because a lot of that was done at Cornell. What they've done is to remove the eyeball and stimulate the optic nerve directly, using a quartz rod transmitting the light. You probably know that quartz will transmit the light in a straight line, and they transmit it right on to the surface of the optic nerve and they're able to stimulate gonadal development doing this. Another common theory, if it is still in a theory stage, is that the organ called the pineal body in the brain which is the vestige of an actual photosensitive structure in lower vertebrates, such as amphibians and reptiles, is still present in birds and mammals and is located in such a position in the skull that it's possible that light is transmitted through the skull. This pineal body may be a very important internal clock mechanism to the animal; they don't think that it has much to do with reproduction. All vertebrates have daily cycles of events that are very precisely controlled. We get longer cycles that have some type of internal control and it's been theorized that the pineal body may be responsible for some of these controls.

HUNTER. I read some work with Mallard ducks, in which they remove the eyeball, cover the eye up, and subjected the light directly on the skull, and they got gonadal development without even going through the optic nerve.

TEMPLE. Well, we've got some interesting observations that Jim Enderson and Jerry Swartz and I made up in Alaska using a time-lapse camera of nesting Peregrine Falcons throughout their nesting season. The photographs were good enough that we could monitor the molt of these Peregrines throughout the reproductive period. Basically what we found was that the molt was not sort of a steady molt throughout the breeding period. The female at the hatching of the eggs stopped her molt; her molt arrested right there and she did not continue her molt until much later on after the young were fairly close to fledging. This may be very adaptive for the birds because when the young are growing of course the female is at a handicap if she'd molt; she's going to have to go out and help provide food, you know. They're going along very steadily; undoubtedly it is tied in to a certain extent with the reproductive cycle. Dr. Awender, haven't you done some work on inducing molts with hormones?

AWENDER. Yes, but that was female sex hormones; it was very closely related to the progesterone, Noroleucate. There are a couple of new ones which I haven't tried yet. This is a strong pregestational and antiestrogenic effect that does it, nothing to do with thyroid.

TEMPLE. Of course, you realize that the molt in most birds seems to be associated with a decrease in the gonads or a decrease in the circulation titre of steroid hormones. This may be a spurious correlation.

GRAHAM. I have a quick question maybe someone can throw some light on. Has anyone thought of why a Gyrfalcon from the arctic brought down will molt in Alaska, whereas the tundra Peregrines brought down from an arctic regime having this different molting season . . .

HUNTER. That's not just the same.

WHITE. No, the tundra birds I brought down molted the same time the rest of the wild population do. I'm talking about eyasses. Eyass tundra birds brought down in this example kept in mid-latitude for three or four years molt at the same time that the wild tundra populations do. Now you're talking about trapped eyasses.

GRAHAM. No, I'm comparing trapped passage Gyrfalcons and trapped passage tundra Peregrines.

WHITE. Eyasses molt at the same place regardless. You take an eyass tundra bird—it'll molt the same time the tundra populations does—they'll start in April and end, you know, in August.

STODDART. I was just wondering with all this discussion, what were you talking about when you talk about tundra birds? Are you classifying the passage

Peregrines trapped on the beach?

WHITE. Of course, when you get a migrating bird, all you can say is that it is from some place further north. I don't want to comment because many tundra birds do appear on the Texas coast, and many, in fact probably some of the western birds that are raised right in Colorado occur on the coast; nobody really knows until we get banding data. What Dick asked was whether birds taken from the Colville River, for example, molt at the same time that the wild population molts along the Colville River. If you were to have a passage bird from the Colville I would wager you that it would not molt at the same time as the eyasses.

STODDART. Wouldn't you think if we are going to birds especially the passagers, that you should match molts.

TEMPLE. The molt of the male and the female are drastically difficult.

STODDART. No, compared to the wild.

HUNT. In regard to bird trapped on the Texas coast, I've never seen one that looks like an *anatum* or molts like an *anatum.*

RAPTOR RESEARCH

Volume 6 Supplement Part J 1972

SPECIAL CONFERENCE ON CAPTIVITY BREEDING OF RAPTORS–A REPORT

Sponsored by Raptor Research Foundation, Inc.
Held at Sioux Falls, South Dakota, U.S.A., November 22-23, 1971

Part J. Reproductive Endocrinology (Panel 5)

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Panel Members: Erich Awender, Chairman, Timothy Lawson, James C. McIntyre, and Stanley Temple.

AWENDER. We will try to get right into things here because this is going to be a more nebulous problem and may be more divisive. I can already see things shaping up from two sides, the practical and theoretical. They do not rule each other out, but I think we will have quite a bit of discussion and not quite so much formal presentation. Mr. Temple will present the basics so that we will know what we are talking about and see in general outline what endocrinology is all about. I am not too qualified to say anything here, because I am mostly versed background-wise in human medicine and I have done very little work with birds. I will tell you what little I know later, but let's start with Mr. Temple, please.

TEMPLE. As Dr. Awender has said, when we are talking about endocrinology of breeding birds, we are talking about the control mechanism. Endocrinology is the study of hormones. Hormones are internal secretions of the body and are the mechanisms by which birds, mammals, and all vertebrates control their reproductive processes. We are dealing with the very intimate control of all of the acts that are associated with breeding. It is a very complicated picture and, unfortunately, the information for birds as a group is very scanty. Our understanding of even mammalian endocrinology, especially of the cycles of various hormones that control reproduction, is scanty; with birds we are even more at a loss. We are fortunate that the evidence collected so far indicates that most

vertebrates have the same (certainly all birds have the same) basic endocrine control of their reproductive cycles. Information that we might gain from studying the endocrinology of a pigeon or a chicken or some other bird is undoubtedly perfectly applicable to birds of prey. Basically, because they are so important to the birds, there has not been a lot of modification of these systems. It is one basic system that has worked. So what I am going to do is go through the endocrine control of a bird's reproductive system, and point out, when I finish explaining it, possible places in this system where problems imposed by captivity may be disrupting the normal function. After I have done this, I might comment a little on ways of helping the birds with reproductive endocrinology problems. I think Dr. Awender and Tim Lawson will follow up with some of the approaches that they have tried.

First of all let's start out with what it is that triggers the reproductive cycle in birds. What starts the cycle is an external stimulus. The responses to external stimuli are probably where birds have evolved all the variation that we see between species. Different species have evolved different sets of external stimuli which trigger reproduction. For many birds, photoperiod—increasing day length—is one of the most critical external stimuli triggering the reproductive cycle. For other birds, climatic factors, such as rainfall, temperature, and other things also come into play, as do important factors such as the interaction between pairs, nest-building and courtship. All of these external stimuli come from outside the individual bird. The external stimuli are received through the bird's senses. Be they visual, auditory, tactile, or whatever, the stimuli are received by the central nervous system—i.e. by the brain. They are then transferred to the region of the brain called the hypothalamus. The hypothalamus you can think of as being an integrating system. This is where all the information is synthesized, and the appropriate messages, if you will call them that, are relayed to the different portions of the brain that will ultimately trigger the production of the hormones which in turn will control the reproductive cycle. The hypothalamus secretes very little known substances called neurohormones. These hormones are secreted by nerves, a very unusual condition, and they are very, very hard to identify. These neurohormones are secreted by the hypothalamus after it has integrated all the information from the external environment. They are then relayed to the pituitary gland.

If you remember your high school biology, the common designation for the pituitary gland is the master gland of the body. Many of the important hormones that control body processes are produced in the pituitary. This is exactly the case with reproduction. The whole thing gets started in the pituitary. This is the gland that will secrete, after it has been triggered, gonadotrophic hormones. Gonadotrophic hormones, very simply, are hormones that will stimulate the gonads. With birds we are very much at a loss in identifying the gonadotrophic hormones. For mammals it is fairly well established. There are two main ones—Follicle Stimulating Hormone, commonly called FSH, and Luteinizing Hormone, commonly known as LH. These two hormones have been identified in mammals as the hormones that control the maturation of the gonads. We

have not yet been able to isolate two separate hormones from birds. In birds there may be one hormone that has both of these functions. But, suffice it to say, the anterior pituitary secretes gonadotrophic hormones which are released into the blood stream and circulated through the body to the gonads.

FSH and LH (or whatever they might be in birds) have two separate functions. FSH in the female causes development of the ovaries. It causes the ovaries to enlarge, to become mature, preparing them for ovulation. In the male, FSH stimulates the development of testes. Birds are cyclic in their gonadal development. During the winter the gonads regress; during the breeding season they enlarge. The enlargement of avian gonads is in direct response to these gonadotrophic hormones. LH, the other gonadetrophic hormone that we know exists in vertebrates, has the function in the female of causing ovulation. Once the gonad has matured, a spike or sudden spurt of LH from the anterior pituitary causes the egg to be ovulated, to leave the ovary, and pass into the oviduct where it will be developed into an egg and laid. In the male, LH does not peak quite the same way it does in the female, or we do not think it does. LH probably increases along with FSH and this is also responsible for the development of secretory products in the gonads.

The gonads not only produce gametes, sperm and eggs, but they are also important in that they secrete sex steroids, the sex hormones, as well. These play a large role in the development of secondary sexual characters, such as the comb in a male chicken. They have a tremendous role in controlling male and female behavior. The way the gonads elicit this is by secreting the sex steroids into the blood stream. We are talking about estrogens. The estrogen that is most active in birds is estradiol. In males we are talking about androgens produced by the testes. The main androgen produced by the bird's testes is testosterone. When released from the gonads into the blood stream, the sex steroids circulate and cause appropriate changes that will prime what you might think of as the accessory breeding organs. It will cause, for instance, the development of the sperm duct that will eventually carry the semen from the testes to the outside. In the female it causes the development of the oviduct, the structure which is going to be secreting the albumen and the eggshell around the egg. These structures are also cyclic, decreasing in size during the winter and increasing in size during the reproductive season. The increase is in response to steroid hormones secreted by either the testes or the ovary. Also, estradiol and testosterone control reproductive behavior. They do this once again by going back through the bloodstream to the brain, to the hypothalamus. At this point, the information on the circulating levels of these hormones causes appropriate behavior. As the testosterone levels in the blood increase, a male bird is stimulated, for instance, to defend his territory or to go through courtship display; a female responds by building nests and all the other courtship displays that are associated with the breeding cycle.

That is basically the cycle of hormones that we are talking about. It is very important that we realize that this is a cycle of hormones. All of these are interrelated; think of it as a circular thing. We are dealing with a situation known as

a negative feedback mechanism—something like a thermostatic control. Let's go back over the system and show how this negative feedback system works. Early on in the breeding season, when the external stimuli become sufficient to cause secretion of the gonadotrophic hormones, the hypothalamus is also monitoring the level of the steroid hormones from the gonads. I am going to be a little anthropomorphic here, but just for convenience suppose the hypothalamus is not detecting very much estradiol or testosterone. The gonads are small; they need the gonadotrophic hormones. The hypothalamus secretes a lot of gonadotrophic hormones to cause development of the gonads. As the gonads increase in size in response to this, they start secreting steroid hormones, either testosterone or estradiol. The blood levels increase. The hypothalamus reads this and says, "There is a high level of steroid hormones; therefore it is time to shut off or decrease the gonadotrophic level." So you can see how this is a thermostatically controlled mechanism. They balance each other out, very critically. This has important implications which I will talk about in a few minutes.

The other thing that is important about hormones and their control of reproduction in birds is that the timing of these hormones is very, very critical. The hormones have to come into play at exactly the right time to cause a synchronous series of events to occur. As I mentioned before, you have to have a gradual build-up of gonadotrophic hormones to gradually build up the gonads. Once the gonads are mature, you need a big spark, or peak, of the hormones that will cause ovulation, the release of the egg. You also have to have appropriate changes in the gonadal hormones, the steroids. These have to build up to a certain level. The intensity of the behavior that they are going to elicit is, of course, a direct function of how much of this hormone is circulated. Behavior, as you know, starts out slowly early in spring and builds up to a peak. It is probably at this peak time when reproductive behavior is peaking. We are talking about copulation and fertilization and the actual events that mean success or failure of breeding.

Now, where might this system break down in a captive bird? There are several places. The first one involves the external stimuli. When you put a bird into captivity, you are obviously depriving it of many of the external stimuli he would normally be getting in the wild. As of yet, no one has cataloged the complete array of external stimuli necessary for a Peregrine Falcon to be successfully stimulated to reproduce. I think we can safely say that photoperiod, the increasing of the day length, is very important. Also, probably, courtship, the interplay between the mates, is also a very important stimulus. Probably, having an adequate nest site is very important. Outside of these very obvious ones, we just do not know. This is where the items discussed earlier on the basic requirements for a successful breeding chamber come into play. It very well could be that some things associated with the deprivation of stimuli in captivity are blocking the whole system right at the start. Another possible place where you could get into problems is in the hypothalamus. It could be that the birds are picking up other stimuli from the captive situation that are blocking the hypothalamus from triggering production of gonadotrophic hormones. Certainly you

know that there are many things that we do with birds in captivity that are unusual in terms of stimuli. At the level of the gonads things can also go wrong. It is very possible that the gonads may not be producing enough of the steroid hormones, the sex hormones, to elicit proper behavior. When we get to the level of the gonads, we can go to an endocrinologist who is very versed in these matters and ask, "We have a bird in captivity; we have done everything we can to make conditions ideal for it, but it will not breed; what is wrong?" First thing he is going to ask is, "What were the conditions of the gonads after you gave this bird all of these sufficient stimuli—or what you thought was sufficient?" This is one place where we are sadly lacking. We have had many failures breeding Peregrines, and I would venture to say that we probably do not even have one or two instances where we knew what conditions of the gonads accompanied the failures. Were these gonads enlarged? Were they anywhere near functional? This is a critical question. If we find, for instance, that they are not enlarged—they are remaining very small and undeveloped—then we can say the problem is with the hypothalamus. If they are enlarged and we are still not getting appropriate reproduction, then we might think of looking at the sex hormones. Is there production of those to elicit the behavior that must accompany reproduction?

These are two points where we might consider helping birds out. We have two groups of hormones at our disposal, the gonadotrophic hormones and the sex hormones. I would first of all, as a physiologist, caution anyone from using these hormones in a bird for which you have not examined the gonads. Remember, this is a negative feedback system. You must know what the condition of the gonads is in your bird that is not breeding. You may well screw up the bird even more by giving it an inappropriate hormone. For instance, let's say that your bird is not doing anything. You say, "Well, I'll give the male a shot of testosterone; that ought to make him reproductively inclined." In fact, it will. If you castrate a bird and give it supplemental injections of testosterone, it will go through all of the appropriate reproductive behaviors, including mounting and copulation, but, of course, if the testes are removed, it has no sperm to contribute. So, let's say you go ahead and try injecting testosterone; let's say that was not the problem; let's say that the bird actually did not have gonads that were enlarged. What you have done then is add testosterone. It goes back to the hypothalamus, and the hypothalamus says, "Oh, here is all this testosterone," and cuts off all the gonadotrophic hormones. What you have done, if anything, is to decrease the size of your bird's gonads, because you have knocked out the gonad stimulating hormone. Let's say you do it the other way and make a mistake; you inject gonadotrophic hormones, when, in fact, the gonads are fully developed. What you are going to do, then, is harm the cycle of the testes or the ovaries; the cycle has to build up gradually. What I would caution is that before you attempt any kind of wholesale use of these hormones on the bird, you are going to have to know what the condition of the gonads is in the bird that did not breed for you.

Now, the other thing that makes manipulation with these hormones very

difficult is that for no species of birds, including chickens, do we have any information on what the normal circulating levels of these hormones are. We have ballpark estimates, but we have no information at all on what the level is, for instance, during the peak in the breeding season. We have no idea what the concentrations of sex hormones are in the blood of even a breeding chicken. As I said, these hormones are very precisely involved in this cycle. If you are going to attempt to induce breeding in a bird by injecting exogenous hormones, you are going to have to be very sure that you are going to be able to inject these hormones in the proper sequence, at the proper concentrations, at the proper time. Otherwise, you should not expect to get sure-fire results. There have been reports in some of the literature of people who have stimulated certain birds. In fact, the only successes that I know of that have been published, have been achieved with small finches. They have injected sometimes artificial gonadotrophic hormones, sometimes naturally occurring mammalian hormones. These successes are not really adequate to say that it was the injection of hormones that ultimately triggered the birds to lay eggs. The birds grew up under conditions that were definitely stimulatory to gonadal development, and it was not a very well controlled experiment. What I am trying to say is that the researchers did not show that, in fact, these hormones were the responsible agent.

One very interesting report that I should mention was carried out on Pintails. If you happen to be a waterfowl breeder, Pintails are your Peregrine Falcons. They are very difficult to breed in captivity; why, they do not know. A very well designed experiment was carried out at the Delta Waterfowl Research Station in the late 50's on this problem. The fellow who carried out this study had huge sample sizes of Pintails to work with. He could experiment; he had room to play around, which we do not have with Peregrine Falcons, obviously. He tried every trick in the book; he tried giving them increased photoperiod; he tried varying all the external stimuli he could possibly vary. He still could not get full gonadal development. Gonads would develop to a sub-optimal level, taper off and decrease. He then decided to try the hormones. He looked at the gonads. He knew that the gonads did not reach full condition, so he thought, "Well we'll try gonadotrophic hormones to see if I can beef up the hormone titers and stimulate the gonads to become fully mature." He tried a wide variety of doses on many birds. He tried FSH alone, LH alone and combinations of the two. He tried another hormone which is very difficult to get hold of. He also tried a hormone called pregnant mare's serum. The serum from a pregnant horse has a hormone in it that, as of yet, is unidentified. This hormone possesses the dual qualities of FSH and LH. It is sort of a hybrid form. You can get this very easily from the blood of a pregnant horse. He tried giving this because it's readily available. He gave it in varying doses—up to massive doses—in a complete range and, even with this, he was not able to get the gonads to come into full condition. This is probably because we have no knowledge as to how this hormone should be injected—what the cycle of it should be. He went point blank injecting, and did not get results.

Now, I am not saying that this approach is not going to work; what I am say-

ing is, if you apply the artificial exogenous hormones to a bird, you are going to have to be very careful what you are doing because you may ruin the bird. I do not want to sound pessimistic, because I know Dr. Awender and Tim Lawson have both done some experiments with exogenous hormones that indicate that perhaps there is as yet some response in birds of prey to these hormones. However, just to caution you, realize that in these experiments they were not controlled to show that it was actually the injection of the hormones that was causing the development of the gonads. I hope somebody in this room can pick up the obvious project and look at it with a common species like the Kestrel. If you get a bird that will not breed in captivity, laparotomize it, look at the gonads, and then work from there. That is the first experiment that has to be done.

AWENDER. I will be brief with my own project. I have a very small sample to work with and I am not willing to take any chances to harm the birds, kill them or operate on them; that is the main reason I shied away from injections to begin with. I have ruled out injections. Injectable stuff is very hard to come by, it is expensive, and we do not know for sure whether it would have any significance for birds. Most of the laboratory work that has been done so far involves laboratory animals, usually a rat, mouse or guinea pig, very occasionally a chicken and, once, maybe a pigeon. But the bulk of everything has been done on mammals and has been applied mostly in human medicine with variable results. I do not think many, if any, groups, as such, have applied something therapeutic to birds. It was always on the scientific level. We do not care too much if a chicken does not lay eggs; we kill it and eat it. But with falcons it is a little different. So I have ruled out shots and went to tablet .

My experimental pair, just to tell you what I was working with, are passage-tundra falcons. The tiercel is going on four; the falcon is going on nine years of age. They were ordinary passage falcons. They were trapped at the usual time at the usual place. The female was flown in falconry for about five years, the tiercel for one and a half years. From then on I put them in this project and they have been together since, with one interruption. The tiercel was gone last year for a short time. There is not too much in the line of non-injectable things to stimulate the pituitary. As I said before, I am drawing only from what I can deduce from human medicine, and I have had very little, if any, contact with veterinarians. I do not have the foggiest idea where the gonads of my falcons are. Are they big, little, or indifferent; are they even existent? The falcons were acting in a very neutral way. If the size would not have betrayed the tiercel, I would not have even known which sex they were.

So, at any rate, I thought I would start at the top, from the pituitary. I went ahead last year, in 1970, and put the two tundra falcons in their room where they were going to stay, and exposed them to light, beginning about the first of March. They had light for about a month—about 20 hours a day. It amounted to roughly 500 watts plus daylight. After the first month I put them on 24-hour daylight, figuring if a little is good, a lot might be better. This is a common

thing applied by lay people. This did not do much; there was no change in behavior at all; they were very passive to me and to each other, and stayed out of each other's way. They never perched together. Then I heard about a drug which was producing quintuplets, sextuplets and even eight babies in humans and I thought, great. The more eggs it produced in a falcon, the better. It may kill a woman, but not a falcon: they lay one at a time. This drug is called clomiphene-citrate or Clomid for short. The trade name is Clomid. It is a synthetic thing, comes in tablet form, 50 mg per tablet, and women take it for only five days. Then they are supposed to ovulate, and some of them really do. They go overboard and eventually they abort; they cannot carry them to term—not enough room. So I thought this was ideal for falcons. I figured that if a woman takes 50 mg a day for five days, a falcon needs 0.75 mg per day on a commensurate per weight basis. I could not make it; it was so little. I had to go to the pharmacy and they had trouble weighing out that little for me, but we thought we came close to 0.75 mg. I put it in a little capsule, put it in a piece of meat and gave it to the falcon for five days, figuring to do it just like for the ladies. Nothing happened; absolutely nothing happened. The falcon started her molt a little bit late. That was a pretty complete washout. In order to be good to the tiercel, too—I did not want to inject him—there is testosterone which is fairly effective by mouth if a methyl group is attached to it; it is then methyl-testosterone. In human medicine we use it in doses of 10 mg per tablet and usually one, two or three tablets will do. I gave the tiercel a human dose. It did not kill him; it did not do anything. Nothing! It may have inhibited, as we may conclude from Temple's presentation. At any rate, he had the testosterone for the same time the falcon had her drug. I stopped the experiment and that was that for 1970.

This year I thought, well, let's go one better and prime the falcon with estrogenic hormone. It did not work from the top, so I started from the bottom and gave her something by mouth. The ordinary estrogenic substance is not effective by mouth so I went to stylbestrol, diethyl stylbestrol to be precise, and that comes in my office in half mg tablets. I primed this falcon with diethyl stylbestrol, half mg per day, given by mouth. I started on May 9 and gave it to her until May 28, roughly three weeks. That did not do much at first, but towards the end of that period the falcon became just a little restless. I could not explain on what basis and I did not know if the drug had anything to do with it. She was peaceful usually, but then she sat on the highest perch and beat her wings like crazy, exercising many hours a day. I am not aware of what this meant, but otherwise she left the tiercel alone. It was the same falcon on the same photoperiod. Then, on May 29, I stopped abruptly the diethyl stylbestrol and switched over to the Clomid that I gave her the year before. Again, I gave daily doses, but I really went up high, probably too high because I figured I did not have enough time. I gave her 12½ mg; this is a quarter of a tablet. That is an enormous dose on a weight basis. She took it from May 29 to June 9 and that made a significant behavioral change. She became extremely broody, which she had never done before. She went into her brooding corner and made a

scrape there. She became extremely passive. I could touch her on the back and she did not get up. She acted like Mr. Nelson mentions several times—she acted sick—but she stayed in good physical health. She ate and I could practically feed her like a little eyass falcon; she was that tame and that quiet. I palpated her abdomen to see if she would enlarge things. This drug is supposed to induce ovulation or, at least, get the follicles to mature more. I could not palpate any increase in her abdomen. Laparotomy was out of the question.

I stopped this experiment at that time. After about a month or so she changed her behavior again and this time with a vengeance. She became extremely aggressive to me and to the tiercel. This persists to date. The tiercel has to retreat many times a day. She has crabbed with him several times. My room is 10 feet wide, 15 feet long and the highest point is about 12 feet. If she was nimble enough she could really hurt him; nothing has happened so far, but she has remained, for about a month after I stopped those drugs, extremely aggressive and downright mean to the tiercel. The tiercel received no medication this year. I have just left him alone. He behaved passively, as usual, and now he is constantly a fugitive. The female again postponed her molt even more. She started extremely late. She started about the first of September. Now, of course, she is almost finished; she molted extremely rapidly.

There is not much else I can add to this particular pair. The Clomid is something that has been used in humans successfully, as I said. In the ordinary laboratory animals, and as far as I know definitely on mice and laboratory rats, it did inhibit. It inhibited follicle maturation and ovulation. I thought, perhaps, if it works in people, it may not work in lower mammals. As you can see, with falcons nothing happened. I do not know why, but I think if somebody had more time and wanted to titrate the dosages a little more accurately, perhaps more could come of it. It has one advantage; it can be given by mouth. Most of the other hormones we are talking about here can only be injected and again we just never know where we stand with the dosage. Too much is not good; too little is not good; and whether we start on the top or on the bottom we may antagonize the other part.

I have tried other pairs, but they have not been receiving any hormone treatment. One is a pair of Peale's. I think the passage tundras needed it most. That is why I picked this pair for experimentation. Passage tundras are known to be hard to get into any kind of breeding condition, much less to lay fertile eggs. The others will probably do it naturally. I have a pair of Peale's and a pair of Prairies. The Prairie Falcons have been stimulated with light only and I think they did not do it on a natural basis because the tiercel was too young. The tiercel is a home-bred bird that Henry Kendall bred three years ago. He is one of the surviving tiercels. He has been mated with a falcon that was then three years older. Now he is three; she is six. She has laid eggs on photophasing. I turned the light on one year on December first and left it on day and night. Six weeks later, January 16 she started to lay eggs at the usual two-day interval. She laid a clutch of four. I took the eggs away and put them in an incubator; they were not fertile. I gave her two banty chicken eggs. She alone incubated them well

enough to start them growing. I could see the embryo two weeks later. The tiercel was totally passive. This year the same thing happened, except I started the light later--on March first. The eggs were laid while we were gone skiing at the end of March. When we came back, she had a clutch of four again and the tiercel helped incubate. But, again, they were not fertile. They behaved very well. The tiercel was very aggressive; the falcon was not. She was calm and broody, so I did not disturb the eggs for 32 days. Then I realized they were no good and it was too late to recycle. The moral of this story is: no matter how good it looks, candle on the ninth or tenth day.

The third pair are the Peale's and there is not much to say about those because that pair I will leave alone for natural breeding attempts, not even any light stimulation, because I think they have the potential to do it on their own. The tiercel is three; the female is six. They are eyasses. The female has raised foster babies of her own species in British Columbia. This year, just for the heck of it, I gave her a two week old Prairie Falcon. She immediately adopted it and fed it, but the tiercel did not participate in the feeding. She is a good foster mother. She is of the right age. The tiercel has been broody for the last two years even though he is young, so I hope that next year, just by leaving them alone and giving them good food, they might do it the natural way. It seems like the natural way may prevail over the injectable way or tablet drug culture way, but time will tell. We are just at the beginning.

LAWSON. I think first of all the key in the chart from Stan Temple's presentation is the very first block, the external stimuli. Unfortunately it is not always practical to create rock cliffs and Colville River in your breeding room and I think that most people will agree now, as we have talked about earlier, that the birds seem to realize where they have come from, where they were born, and they seem to always do better in a familiar environment. After they get there, the external stimuli that both initiate this process and keep it going after it is initiated are vital. For example, if you take Kestrels and put them in a breeding room and do not supply them with a nest box, you are wasting your time. They just will not do anything. The nest hole seems to be essential to success. When you take these birds out of their normal habitat, you are confusing them, completely. What we try to do with the gonadotrophic hormones, at least my rationale is, that we are trying to bypass the external stimulus needed to initiate breeding. I have been criticized, and very rightly so, by Stan Temple and John Snelling in that my experiments are not controlled so that I can say 100% that my hormones are doing the job. I am giving them hormones, increased light, warmer temperatures, and total isolation so that the limited success I claim could be any of these or all of them together. I go along with Dr. Halliwell; I do not care if I have to hang an Indian medicine bag in there to get them to lay eggs; I will do anything and this is the basis for my using these hormones. My other big misunderstanding with all breeding projects is that everybody seems to feel that these birds are not affected by human presence. Dr. Meng is living proof that I am completely wrong on this, but I am going to say it anyway.

Adrenalin, epinephrin, is proven to be directly antagonistic to follicle stimulating hormone. When you walk into the room to feed the birds and they jump around being really ill-at-ease, you are destroying everything that you have tried to build up in these birds. It has been shown that adrenalin is directly antagonistic to follicle stimulating hormones. Something else that Stan said was that if you are going to try these hormones, you must inject at the proper times and in the proper amount. I will go along with proper time, but I do not think the amounts are that critical. I do not think you are going to kill them with pregnant mare's serum. When I did this with Kestrels I gave these four-ounce birds one cc of pregnant mare's serum each day, injected intermuscularly, for five days running. That is about half of the dose you would give a 50-pound dog. So I am really whopping it to them. Dr. Awender seems to correlate that you have to increase the dosage far above what you would calculate for the weight of the bird. You have to do it at the proper time or you are defeating the bird's natural mechanism. If the gonads are beginning to develop and you give them follicle stimulating hormone or testosterone, the chances of success are nil. But I just do not believe that the amount that we are giving is that critical. I started off with Kestrels and we did perform a laparotomy on these birds to check the gonads before we started. The birds were captured about 35 miles apart on purpose to preclude their being a naturally mated pair, and we did this in mid-December. We gave the birds five injections and then left them alone, trying to initiate a response with hormones, and then let nature take its course. We let increased photoperiod and lack of disturbance take over. We have done this with Kestrels about five times, with Red-tails twice. With the Kestrels we got copulation in 11 days from capture and eggs laid in 33 days. With the Red-tails we never did see copulation, but we got fertile eggs 47 days from capture.

STODDART. When did you give them more light?

LAWSON. Immediately, 16 hours of daylight.

STODDART. You gave them injections of hormones?

LAWSON. We gave them one injection a day for five days. Before we even put them in the breeding room, we gave them the first injection.

VOICE. The tiercel as well as the falcon?

LAWSON. Both.

MARCUS. Tim, when you gave five shots did you keep them jessed up for five days and catch them?

LAWSON. No sir. These were wild birds; they were not manned. They were kept behind a one-way glass all the time with no external disturbance whatso-

ever as far as sight is concerned, just the noise that normally occurred.

MARCUS. How did you give them shots for five days?

LAWSON. Catch them at night. They never saw us.

STODDART. Do you think that causes adrenalin production, i.e. handling them at night?

LAWSON. Not nearly like going into the room would cause. It takes two minutes to do this.

HUNTER. In conversation with you before, we discussed the site of injection with Peregrines.

LAWSON. We were giving these birds 6 cc a day which is a whopping dose for the breast muscle of a Peregrine, so we went to the subcutaneous tissue behind the neck where you are going to get equal absorption. I am sure that you are going to get the same results.

SCHUBERT. You put it all in one area and it absorbed?

LAWSON. We did not have any trouble with soreness or any sign of discomfort whatsoever. In correspondence with Dr. Graham, I am sorry he is not here, he mentions that he had trouble with what he thought was a bad reaction to this foreign protein. Pregnant mare's serum is serum from a pregnant mare, just like it says, and it is a foreign protein. I think everybody is familiar with serum sickness or has heard about it. It has been shown that you can take a guinea pig and give it a shot of pregnant mare's serum, wait ten days and give it another shot and it will die in 30 seconds right before your eyes. But we have had absolutely no problems with this in our birds.

STODDART. Where were the Peregrines from that were used?

LAWSON. Don Hunter's Peregrines.

STODDART. Were they tundras or Peale's?

LAWSON. They were tundras.

HUNTER. Maybe you ought to explain what the Peregrines did.

LAWSON. I'm sorry you asked that. The first pair of birds Don sent me, the female had been in captivity I don't know how long, but she was pinioned on one side.

HUNTER. She had a bad wing.

LAWSON. The tiercel was fine. I wish I had my notes here with me, but I do not. I forget how many days it was exactly. It was around the normal time that we would expect to see some action. The female began to cluck and show amorous tendencies toward the tiercel and beg to be fed. She started to scrape and the tiercel would not run away from her. He would sit and eat within a few inches of her feet and a couple days later she died of what was diagnosed by the pathology department at Ohio State as gout. But, on autopsy, the follicles on her ovaries were about an inch in diameter, which is a lot bigger than they should have been if she was regressed.

MARCUS. Was the biggest one an inch in diameter?

LAWSON. That was the biggest one. And they were graded all the way down. Somebody asked me when that was. It was the 29th of February.

MARCUS. Have you ever done any repeats on this?

LAWSON. Just with the Kestrels. Just the five trials with Kestrels and twice with Red-tails. The second time with Red-tails was with the same pair. I gave the hormone without doing another laparotomy to see the stage of the gonads.

MARCUS. What do you mean by a laparotomy?

LAWSON. A laparotomy is just to make an incision and look at the gonads, physically, to see what size they are.

MARCUS. Is there any work similar to yours without exogenous introduction of hormones?

LAWSON. Cade and Willoughby of Cornell did this with Kestrels. We patterned our experiment after them almost totally with the exception of the hormones. They got an average of 54 days with variants of 52 and 61 days before eggs were laid by their Kestrels. That is the sole basis on which I base my decision that maybe these hormones had something to do with getting the first egg in 33 days in our experiments. I have no controlled experiments using eight hours of daylight and hormones to prove that it was my hormones that did it exclusively.

TEMPLE. Tim, were your birds maintained in a heated building?

LAWSON. The temperature in the building was about 40 degrees.

TEMPLE. Temperature definitely is shown to affect the rate of development

of gonads. The pilot experiments with American Kestrels that Cade and Willoughby did, were done in January outside in Syracuse, New York, which was very cold. This might explain the time difference.

LAWSON. Absolutely.

SNELLING. Tim, could you tell us what happened after the Red-tail's eggs were known to be fertile?

LAWSON. They were put in an incubator and the incubator went wild at night and killed all three of them. What we should have done, hindsight is always better, was just leave them alone, and let them recycle on their own, but we panicked and initiated new injections. I am sure we fouled them up.

HALLIWELL. I was unfamiliar, or did not catch exactly what you did with these Peregrines. You injected 6 cc in one massive dose, subcutaneously, behind the neck—one dose and then sat back to see what would happen.

LAWSON. Not one dose, five doses.

HALLIWELL. Six cc for five days?

LAWSON. Right.

HALLIWELL. Whereas in your Kestrels and in your Red-tails you gave one cc per day for five days. All of the injections were subcutaneous, not intermuscular?

LAWSON. No, the Kestrels' doses were intermuscular, the Red-tails' were intermuscular, and the Peregrines started out to be intermuscular for the first two days, and then we got to being afraid that maybe we were going to cause some kind of myasitis by giving this in the breast muscle, so we went to the skin behind the neck, which is voluminous. You could inject probably 10 or 15 cc back there and still have a little room. It is a much better place.

SHULTZ. If you had success with one cc in the Red-tails, why would you use a six times larger dose with Peregrines?

LAWSON. The Red-tails were given three cc for five days. We took that figure right out of the air; no basis behind it whatsoever, other than it was a massive dose for a bird of that weight. We had previous luck with a massive dose in Kestrels, so we just took three cc and then we went to six in the Peregrines after we failed to get results the second time in the Red-tails.

SHERROD. Did you use five doses of six cc each, or five doses of three cc on

the Peregrines?

LAWSON. We gave five daily doses of six cc per bird.

PLATT. In your opinion, what do you think happened to the female Peregrine? It was not gout.

LAWSON. I do not know. I found her in trouble in the morning at 10:00 and at noon she was dead.

STODDART. Would follicle size have any effect on it? Were they not particularly large follicles?

LAWSON. Oh no, that would not make her die, if that is what you mean. That was the response I was trying to get—increased follicle size.

STODDART. Was that a normal-sized mature follicle?

LAWSON. Not quite; it was growing; it had to grow half again that big before it would be ovulated.

STODDART. I thought you meant that it was overly large.

LAWSON. No.

STODDART. Now what?

LAWSON. Now what? I came in the Army in July and I have been on TDY since then and have not had enough time to get back to it, but I am going to.

STODDART. This was done on a Ph.D. at the University?

LAWSON. No, this was done on my own time while I was attending veterinary school, but not in association with any university. I used some university facilities because I begged for them, but that is the only connection.

STODDART. Is anyone continuing the work there?

LAWSON. Nobody is there now to do it, no.

MENG. Just one comment. You mentioned before the adrenalin that my Peregrines secreted when they were frightened. Actually they were not frightened. I did not subject them to fright actually; I did not go in there and scare them because I feel that is very bad; that just fouls everything up. I approached the cage from the outside, put food there in a very cautious manner and then

he started defending his territory. I cowered away and just took off, but it was not to the point of his getting frightened. He did not secrete that much adrenalin. If I went in the enclosure he would get frightened and that would probably have defeated the whole purpose. It was just like in the wild where they defend their territory a little bit, but they were not frightened to the point where he went the other way.

TEMPLE. I might add—Tim has seen the paper—the paper that proves that adrenalin will block reproduction only if given in unphysiological or massive doses. The doses were given attempting to use it as a birth control technique in mammals. So, probably, the adrenalin secretion that you would cause by getting a bird to defend is probably insignificant. I want to propose something to you to see what the general opinion is. I am doing my Ph.D. work on just this problem. I am measuring all four of these hormones, FSH, LH, estrogen and testosterone in Starlings because I can get hold of lots of Starlings around here and I have the facilities at hand to measure the amount of these hormones in the blood. How many of you—just to see whether it would at all be workable—how many of you who next spring fail in a breeding effort, would be willing to allow me to take two cc of blood from your bird and analyze it for these sex steroids? All I need is about two cc of blood and I can do an analysis. For Peregrines that is nothing; they can take that loss of blood very easily. It does not even have to be Peregrines; it can be other species. If I could measure the sex steroid levels in the blood, I could probably say whether the bird does in fact have gonads that are functioning normally.

STODDART. What about the females that are laying eggs?

TEMPLE. I would not want to touch it; that is why I said an unsuccessful attempt.

STODDART. What if the eggs are infertile?

TEMPLE. Okay, then.

STODDART. If you candle those eggs on the ninth day, let's say, and you analyze the blood that day, what are the chances of establishing good baseline levels for that point in the breeding cycle?

TEMPLE. What it would do is give us a standard and I could then compare. I could say, "Okay, this is what her sex steroid level is; let's take a sample from a bird that does not lay eggs; what is her sex steroid level?" If it is lower, then you would definitely say that her ovaries are not developing; she is not producing sufficient estrogen to supply the vesicle.

HUNTER. If you can work this technique out first, you can do it with one

drop if you want to. Could you check the phospholipid levels? There is a correlation, too, between the phospholipid, apparently, and the state of gametogenesis.

TEMPLE. Right. This is especially true of the male. Phospholipids are naturally occurring fatty types of chemicals. They are precursors for estrogen and testosterone. They are involved in the production of these hormones.

SMYLIE. What would be the requirements for getting the blood to you?

TEMPLE. Physically what you have to do is collect the blood and immediately centrifuge it to separate the plasma portion of the blood. You have to have a doctor do this who has a centrifuge. It is very easy to do. You freeze the plasma immediately.

AWENDER. I would like to give a chance to our other panel member, Dr. McIntyre, to present his case and then we will have a little more time for questions and answers. I know this topic has a lot more questions than answers, but let's get to one more panelist, please.

McINTYRE. I really do not have very much, because we have not fooled much with hormones. I am going to throw out something here that perhaps some of you know and some do not. When I first got into this business, Dr. Berthrong, a pathologist at Penrose in Colorado Springs, had done a lot of postmortems on falcons. He asked us to look at the adrenals every time we posted a bird. He thought the adrenals were much smaller in captive birds than they were in the wild. We tend, also, to believe this. What effect do small adrenals have on the stimulation of sex hormones, ACTH, corticosteroids, and so forth, I really do not know but some of you experts may, perhaps.

TEMPLE. On this point, the one naturally occurring stress hormone, a hormone that is produced when an animal is under stress, is corticosterone produced by the cortex of the adrenal. This is known to inhibit production of gonadotropin. As its name implies, corticosterone is a steroid. Structurally it is very similar to the sex steroids. This circulates in the blood. When a bird is stressed, the titers are high, it goes to the hypothalamus. The hypothalamus is sometimes (pardon me for being anthropomorphic) is sometimes sloppy in reading the message. Many different types of steroids will be identified by the hypothalamus. It is shown that if you inject corticosterone in physiological doses into a breeding bird, you knock out the negative feedback system because the hypothalamus interprets this steroid coming from the adrenal as a sex steroid. This is another thing we are going to do at Cornell. We have Red-tails that breed perfectly normally—that are at ease, and we have others that do not. We are going to take blood samples from them to measure the corticosteroid level and see if there is a contrasting difference. This will be done next year.

EBERLY. Is there any variation at all in the various brand names of pregnant mare's serum?

LAWSON. Let's see, the one I was using is called Gonadin. I can not remember who makes it.

VOICE. Upjohn.

LAWSON. I think Donomone is another one.

AWENDER. I think Entruitrin-S might be another one.

HUNTER. If you have any more questions, you can direct them to some of the other people here for just a minute. We are going to proceed next with the artificial insemination part of the program during which there will be some demonstrations. Immediately afterward we will take a break and there will be some slides outside which you can look at, hopefully some live sperm under the microscope.

MATTINGLY. In your presentation, Dr. Awender, at a certain stage you said that laparotomy was out of the question. Might I ask you why this was?

AWENDER. Yes, I simply did not want to hurt them. I could do it easily. I cut and sew in the morning, every day in the morning; I could do it at home in the afternoon, too. But I do not like to do it without anesthesia. I know birds can stand it. I have operated on them when it was necessary. I would much rather do an open reduction and internal fixation on a broken bone of a hawk without anesthesia or very little anesthesia. They can take pain better than anesthesia, I think. I thought this was going to throw them too far off to grab them; to make a little incision there, then look, and then sew them up again. I thought it would not be the right thing for me to do with one sample, with one pair. If you have a bigger sample to work with, then it becomes statistically important. Here I know my explanation would have been she did not lay eggs because I cut her.

MATTINGLY. The question is being mumbled around back here. I think we saw the same thing when Stan asked about taking blood. I think we are a little too over-protective about our birds. Actually, do you hurt a bird when you laparotomize it?

AWENDER. I think they have some pain and, probably, it involves enough handling that if you do it with or without an anesthetic it may have far reaching effects the next day or two days later. We simply do not know. I favor experimentation with dispensable birds. Take buteos; take Kestrels if you must. I was not going to use my Peregrines. That's all.

MATTINGLY. But, we are not getting any information.

AWENDER. I admit this is quite a shortcoming. I was not about to do it. I am not that scientific.

MATTINGLY. By the way I have been working out dosages for a new very effective anesthetic called Ketelar or Ketamine.

AWENDER. Ketamine. Yes, we use it.

MATTINGLY. Very, very good. I have no worries about it. You can double the doses.

AWENDER. Yes, it splits the mind. I have not tried it, but I know people who do and it's OK. On people it works fine. You hurt them and they do not know it.

HALLIWELL. I think concerning anesthesia in these birds we have also used Ketamine and have had very good success with it in all ranges and sizes of birds from Golden Eagles all the way down to several Kestrels. We feel we have had better success using the inhalation anesthetics of which you are familiar. There are probably two on the market today: methoxy fluorane which we have not had as good a success with as we have had with the also halogenated ether called Halathane. And here, again, with Halathane we have done an extensive amount of work, although I will admit this has been done in a veterinary clinic where we are able to monitor blood pressure, heart rate, EKG, and so on. Because we have had excellent success with it, I feel reasonably competent to use it in a field situation. We have done over two dozen Kestrels, without a death. I pinned a wing on a baby owl approximately six months ago; we have also used it on the larger birds. I think very definitely that it would be worth using and I would be willing to talk to anyone who would like to undertake this sort of project. I think with either of these drugs the risk is not great at all used under judicious care by somebody who has some reasonable amount of experience.

SNELLING. With respect to laparotomy I must admit that I feel the same sort of twinges of pain when I think about laparotomizing a Peregrine. However, there has been some extensive laparotomy done on haggard Red-tails by a man who could not come today. He is a graduate student at Cornell now. And he did a similar study with haggard Red-tails injecting levels of PMS into them several years ago and he laparotomized these birds, I think, two or three times a week, completely putting them under with anesthesia every time he did it. His sample size was approximately 25 to 30 haggard Red-tails. He never experienced any difficulty. So, judging from the experience of poultry people who will tell you that a laparotomy is nothing, I really think that the risk is pretty minimal. Perhaps some of us should begin to think about this technique.

TEMPLE. I might add that when we do laparotomies on poultry or pigeons, for instance, we do not even use anesthesia. The incision that you have to make is in the very thin wall of the rib cage. It is not an area where the animal is going to experience a large amount of bleeding as long as it is done correctly. It is a very simple thing, but it takes experience.

AWENDER. I think we need a lot of help; more work needs to be done. What the Cornell people are doing is wonderful, and I would suggest that they go into it with all their might and do a lot of experimenting. I expressed here before that I was unwilling or emotionally unable (or name it what you want) to experiment with the birds in my possession, and I think a lot of small breeders may feel this way. We are too close to the birds. I think an impersonal approach is needed. One thing that was not mentioned here in endocrinology is this—we have been working on material that has been derived from veterinary sources or from human medicine. It is possible that there is a species specificity of some of these things. FSH as we know it may not work in birds and the only analogy I can draw is this: about 15 years ago or so I was dreaming; I thought in those days I would never have a Gyrfalcon in my life so I was going to make a Prairie Falcon grow bigger, and I was going to give it growth hormone. I could not get any, so the closest thing to growth hormone was a human pituitary extract closely resembling the pregnant mare's serum, a thing called Entuitrin-S. This was supposed to be contaminated with growth hormone and I thought I would utilize the contamination and I shot this Prairie. I got this eyass as small as I could; it still was about a ten day old chick, but I thought the skeletal growth was still backward enough. I gave it daily injections of Entuitrin-S and it developed into a beautiful, normal, lovely Prairie, no bigger, no smaller. And then I contacted Dr. Riddle who had done a lot of research in the early 1930's with prolactin; this hormone was not mentioned here. It is a very definite avian thing. It does not have much practical value and so we thought prolactin might be a growth stimulating factor or the growth hormone for birds. It just goes to show that what may be growth hormone for mammals may not be the same thing at all for birds, and that goes for all other hormones. Some of them are definitely showing effects; some of the others are not; I think this making extract from pituitaries of birds will become a major project. It has been suggested to me to hire some high school kids and let them take the things out of chicken hatcheries and so forth, but the little fellows cannot do it. I would obviously appreciate some help from Cornell, and I would gladly inject some stuff and watch one or two birds. But, I cannot make the stuff and I do not think most amateurs can.

HUNTER. I looked into this avian derivative of Follicle Stimulating Hormone several years ago and I ran into a brick wall.

AWENDER. Right.

TEMPLE. We do at Cornell. I might say that to get usable amounts you go through tons of chicken heads.

HUNTER. Yes, that is right. I had a serum company tell me they would make it for me, but I hate to tell you what they said it would cost.

SHULTZ. Stan Temple has mentioned that if we would send him two cc of blood from our birds that he could run some analyses, and I think this would be extremely useful and extremely helpful. From this group, I am sure that we could get enough samples to make it significant. Would you repeat this for the benefit of the people who were not listening?

TEMPLE. I think what I will do is publish a note in the next issue of *Raptor Research News* that is going to get to everyone, rather than right now.

VOICE. Do you only want falcons or do you want buteos and accipiters or what?

TEMPLE. I can assume the cost of some of these analyses, but every sample is going to cost me about $10 and about 16 hours of work to analyze it, so I would prefer to limit it to Peregrines for the time being because of the time and expense involved.

HUNTER. It certainly was my feeling during this reproductive endocrinology session and has been for quite a long time that this particular field does have some real possibilities, although I do not think that it is anything for, as Dr. Awender says, the little fellow. It needs to be done under controlled conditions and I am hoping that Dr. Lawson will find time to pursue his work a little further.

RAPTOR RESEARCH

Volume 6 Supplement Part K 1972

SPECIAL CONFERENCE ON CAPTIVITY BREEDING OF RAPTORS–A REPORT

Sponsored by Raptor Research Foundation, Inc.
Held at Sioux Falls, South Dakota, U.S.A., November 22-23, 1971

Part K. Health and Nutrition of Breeding Pairs (Panel 3)

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Panel Members: William H. Halliwell, Chairman, David E. Allen, C. Wendell Carlson, James McIntyre, Richard D. Porter.

INTRODUCTION–NUTRITION

HALLIWELL. I think nutrition is well exemplified by a little joke I heard a while back. It is a story about a farmer. One of his banker friends said, "Farmer Jones, why don't you go back to school and learn more about farming and then you could come back and do a better job of farming and have better crops and increased productivity." And Farmer Jones said, "Shucks, Banker, that won't do any good, I don't farm as well as I know how to now!" I think the same thing applies to those of us trying to breed birds of prey, and I speak in particular reference to the nutrition of birds of prey. What I have tried to do today is to go through some of the scientific basis of fact for the nutrition of birds of prey.

Pure and simple, nutrition is the transformation of food into living tissue, but this takes a lot of things from the time you lay it out to the bird until the time the bird transforms it into living tissue. In order for a diet to be adequate, it must first provide food for sufficient energy. Second, it must contain all the essential nutrients in correct quantities. Thirdly, it must be digestible and have a high biological value. By biological value we mean how many nutrients it has–vitamins, minerals, carbohydrates, proteins, fats. All essential nutrients must be

CARLSON. No. What you are doing by the high protein diet is increasing the number of B-complex vitamin requirements. But if they are satisfied it should not really hurt the animals. Protein is just as good a source of energy as starch.

HUNTER. I mean during the reproductive stage . . .

CARLSON. I suspect the first thing you might notice is smaller egg size if energy is really markedly deficient. I think if they had plenty of protein they would still be able to concentrate it.

GRIER. I don't remember the trace experiment. There was a man who studied rickets, and there were two groups one of which was fed chopped up feathers from chickens that had been irradiated and got rid of their rickets. The other group had not been irradiated and did not lose their rickets. So I think there is some possible Vitamin D synthesis going on here.

TEMPLE. One thing you have to be aware of, you are talking about a bird where this ultra-violet light is not reaching the skin. A bird has very little exposed skin—the synthesis is taking place apparently in birds on the feathers themselves not reaching the skin. There is no way that ultra-violet light could reach the bulk of the skin on birds. It reaches of course on the face and beak.

WHITE. In birds it is hypothesized that the reason for preening is to take oil out from the uropygeal gland, put it on the feather, and then as they repreen, the oil on the feather is irradiated and as they repreen they then take this back into their mouth.

GRIER. I think that whole thing has been pretty well discounted. For example, the experiments were repeated but without success, and there have been recent literature and reviews pretty well discounting the whole thing; it seems they do get enough radiation through the feet and lores and ceres.

TEMPLE. What he did when he discounted was to say that probably the irradiation of oil on the feathers into Vitamin D is minimal compared to the dietary sources. The primary sources of Vitamin D are dietary, coming from whatever the bird is feeding on.

HALLIWELL. The relationship of ultraviolet light and Vitamin D_3 or usable metabolically active Vitamin D and the absorption of calcium from the gastrointestinal tract was brought up and I wonder if you would speak in the general area of Vitamin D production in birds as well as the utilization of Vitamin D.

CARLSON. If birds are exposed to about 15 minutes of sunlight a day the kind of sunlight we have most of the time in South Dakota you shoudn't have to worry about Vitamin D. Of course this isn't always the case and when you

that egg, the eggshell must sustain life of the embryo through hatching. Maybe that's the reason we are getting some of the early embryonic death; that is what I am really trying to say. I went through the literature for 1969, 1970, and 1971 over the past months and I have tried to pull out facts from the literature pertaining to early embryonic death as well as to the adult male and the adult female.

I would just like to list these specific entities that were directly related to health and nutrition of adult birds that would be interesting to you, such as *Vitamin A.* In studies with poultry when you decrease the amount of Vitamin A, you decrease fertility of males, decrease fertility of females, get embryonic death at two days after laying the egg. The young embryo metabolizes almost all of the Vitamin A in the period of time from the laying of the egg until that embryo pops out of the egg. And this is one of my reasons for being somewhat reluctant to suggest or even condone the feeding of day-old chicks. I think Dr. McIntyre has corrected this situation himself very excellently and I really think I agree with him as far as ease to the individual falconer. You can buy the baby chick locally or even buy them from Sears and Roebuck for a very reasonable fee, put them in a brooder, grow them to young adulthood about four to six weeks of age. Feed them on a good quality starter feed and follow the recommendations. Feed their best feed, take good care of these chicks until they are four to six weeks of age; at that age take them out of their brooder, wring their necks, put them in a baggie and put them in your freezer. Don't gut them, don't pull the feathers off them, cut the feet off them, leave the head on and put them in your freezer. As you need, pull them out and feed your birds. What are you doing here? First thing, trichomoniasis, what we call frounce and the pigeon fancier calls canker, will not exist after 18 hours of freezing so you can take the most trichomonad infected pigeon, freeze it for 18 hours and you can feed it to my birds.

The next thing I want to discuss is *Vitamin C.* You are all familiar with Vitamin C or ascorbic acid—it's been known since the day of the limeys. Low quality, low amounts of Vitamin C in the diet are reflected in poor albumen quality meaning low protein for the albumin of the egg. Now I don't know whether this has any effect at all on the livability of the young chick that's developing in the egg but it seems to us that if the protein quality is down, the chick has less chance of survival. So I'm just mentioning it for what it's worth.

Vitamin D can be fed as an inactive form which can be activated by the action of ultra-violet light with the skin. But you can also feed the active form. So I think you ought to make amends one way or the other to have vitamin D in this bird. Vitamin D is absolutely necessary for calcium absorption by the intestinal tract. You can feed a bird pure calcium phosphate rock and if he doesn't have enough Vitamin D, he won't absorb any of it, it comes out the other end the same kind of rock. The lack of Vitamin D inhibits egg production which again is tied up with the calcium.

Choline, methionine, and Vitamin B_{12}, high levels of these nutrients, increase egg production and increase egg size in birds. ***Vitamin E*** is involved in feather

coat; it's involved in ovarian and testicular function. It seems to have a very good ameliorative effect on stress, meaning if these birds go into a captive situation after being trapped, perhaps they are utilizing Vitamin E at a faster rate and an adequate supply of it may help us acclimate these birds to captivity.

Calcium I have already alluded to, but to stress it further, normal laying hens when put on a deficient diet, reduced their laying ability by more than 50% within a week or ten days and that's a pretty significant thing to consider.

Diethyl stilbestrol and *methyl testosterone* seem to have a relationship to egg production and fertility.

Phosphorus and calcium go together. They have to be present in sufficient quantities, they have to be present in the correct ratio, and they have to have Vitamin D for this. *Sodium* is also required in the diet. *Selenium* seems to be important in raising young chickens; on a selenium deficient diet they got poor growth in young chicks. *Manganese* is another mineral; it again is tied in with the calcium and phosphorus ratio. *Magnesium* is the same type of thing.

Protein. Poultry grow best on a ratio of approximately 20% protein. This can be lowered with commercial poultry. However, they find that for unadulterated protein, you need about 18 to 20% for the chickens to maintain good growth rate or good egg laying rate.

SWARTZ. Arginine as well as methionine are I believe essential amino acids in birds. They are also important structural components in feathers and hair. At least it occurred to me as a possibility that maybe here when the ingestion of feathers might have some meaning in terms of a specific nutrient.

HALLIWELL. To further elucidate that, methionine is the first limiting amino acid in protein synthesis, meaning when you have decreased protein synthesis it is probably due to a deficiency of methionine. Now I am not willing to express myself on whether all parts of the body contain methionine and other amino acids, but you are correct in that feathers do have quite a bit of methionine.

VITAMINS

CAMPBELL. Why do you add Vitamin A and carotene to the diet?

HALLIWELL. I frankly don't know why they added both. Carotene is a precursor of Vitamin A, meaning that carotene is converted into Vitamin A. It may also go into some other enzymatic reactions and just about every reaction in the body is controlled by enzymes—it may fit in there or some other reason unknown to me.

HUNTER. Do you think there would be any chance of getting into difficulty when there is an imbalance between protein and energy, in other words you have very high protein and low net energy?

CARLSON. No. What you are doing by the high protein diet is increasing the number of B-complex vitamin requirements. But if they are satisfied it should not really hurt the animals. Protein is just as good a source of energy as starch.

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are in captivity you do have to supply it in the diet. As you mentioned there are Vitamin D's. Any of the Vitamin D's that are used for most of our large animals are not potent for birds. Birds must have Vitamin D_3 or calciferol and we find just recently that this is modified by the animal. And even a more potent form could be used, but calciferol or Vitamin D_3 certainly at the present time is the most acceptable type.

TEMPLE. I talked with the nutrition people at Cornell and asked them about the calcium-phosphorus-Vitamin D complex. They came up with a very simple dietary supplement that answers a lot of the problems. That is powdered nonfat dry milk. That milk product has a very high and a very well-balanced calcium-phosphorus ratio. Perfect for birds of prey, in fact. It also has calciferol in it.

CARLSON. Well, I wouldn't expect it to have very much. I would certainly not rely on milk as a source of Vitamin D. But as far as calcium-phosphorus, you can't beat milk.

THOMAS. The person that wants to use supplements would like to know what is the best supplement to get your D_3 from and what do you have to have to make it available to the bird? I wonder what I need to look for as far as carotene. If I get Vitamin A in liquid form, is it available to the bird biologically once it gets in the system? You can get pellets or tablets, whatever, it's got A and D, but if it doesn't say is it D_2? Is it D_3? The only thing that I've been able to find is a stuff called Linotone, it's a coat conditioner for dogs, and it's very high in Vitamin A and D_3, it's got a lot of it in it, and I give the birds a half a teaspoon split between them every day but I don't know whether the D_3 in this is biologically available to the bird. I suppose if we could know more about supplements, as to availability this might be one more practical solution that we could use.

GALICZ. What may be a source of Vitamin D, artificially or supplementary?

CARLSON. Well, we buy it in ton lots as irradiated calciferol. We have any number of vitamin supplements that are used in poultry feeds that you can buy at your veterinary supply house that have potent Vitamin D.

VOICE. What about what you can pick up at a drug store that has the cod liver extract type of thing?

CARLSON. That would be fine.

VOICE. Does it have calciferol?

CARLSON. It has calciferol. You want to stay away from irradiated yeast

and irradiated vegetable products. That is Vitamin D_2.

HALLIWELL. This brings another question to mind again. People are supplementing their diets with additive vitamins. I have my own opinion but I would like yours on the danger of hyper-vitaminosis or hyper-nutritionalism due to if one drop is good five drops is five times as good, a type of syndrome which we all fall prey to.

CARLSON. Well, of course, of most of the commercial feeds we see we don't see a stated potency as far as vitamin activities are concerned. For example, if we were thinking about Vitamin D in terms of the laying hen about 100 international units per day should be plenty adequate. We could go as high as, however, let's see it's about a factor of 20, in other words up to about 2000 international units and still not be toxic to the bird. You can't do that with some of the others, however. Vitamin A will cause you difficulty rather quickly if you get above about 25-50,000 international units per day. So again I would like to temper that by saying it depends on the type of multiple excesses that you might give the bird. Chances are that you could go to three or four times the recommendation and still not hurt the bird or its reproductive potential because there is quite a wide range between requirements and toxicity as far as most of the organic vitamins. The same thing cannot be said for the minerals. You can certainly put in an excess of minerals very rapidly. This should be of greater concern as far as I'm concerned.

HUNTER. In ruminants it is very important for the utilization of Vitamin A to have Vitamin E. Now are you suggesting that in these frozen chick diets, we might supplement with Vitamin E? And D?

HALLIWELL. I Frankly don't think so. Now this is my own personal opinion. Vitamins A, D, E, and K are all fat soluble vitamins, that is they exist in the subcutaneous, the abdominal, the heart fat and unless some oxidant has gotten into this chicken, such as long freezer storage, there should be sufficient amount of these vitamins in the fat on, again over four week chicks.

CARLSON. As far as Vitamin E and Vitamin A interactions are concerned, basically it is Vitamin A that the bird is really needing and Vitamin E is sort of an antioxidant that protects Vitamin A; at least that's the latest. We have had a lot of go arounds as far as Vitamin E as to whether it is really essential or not. About 15 years ago some work came out showing that it was not essential. Then five years later some people reported that it was essential and so on. But at the present time it is thought that selenium, one of the minerals, apparently produces or carries on all of the activity normally we thought Vitamin E was doing. If we have an adequate amount of selenium available for the animal we can very definitely show that the Vitamin E requirement is greatly reduced. So that basically the large amounts of Vitamin E that we usually put into animal feeds is

there to protect the Vitamin A to a large extent. Well that means of course we could use other things besides Vitamin E. We could use any one of a number of commercial anti-oxidants that are available today.

HALLIWELL. Many of the birds that we have in captivity today are over five years of age and they may or may not have been at some time during the first years on a deficient diet. Could you discuss the effect on the reproductive organs of previous nutritional deficiencies. In other words, the bird that is metabolically nutritionally deficient two years ago and on adequate diet today, would you expect damage to the reproductive organs of a bird today? Or do you assume that they will rejuvenate?

CARLSON. It depends only on the deficiency that you encounter. As far as Vitamin E deficiency is concerned, and again it depends on the extent of the deficiency, if it were an extreme deficiency, of course, it is irreversible. It wouldn't do any good to try to correct a bird that had been so handled. But I don't suppose that they would have survived either. Generally speaking I would say unless it is one of these more critical nutrients, if it's just a marginal deficiency, I believe when you get a bird back on a normal diet that their reproductive capacity would recover as well.

HUNTER. It seems to me that there is an area here that we need to hit quickly and this is supplementation of vitamins to whatever diet we are using. Can you go wrong in having too much vitamins?

HALLIWELL. Yes, you can have hypervitaminosis.

MINERALS AND WATER

HALLIWELL. For minerals to be utilized by the body they have to be there in sufficient amounts and there are interrelationships between them, they have to be in some particular form so they can be absorbed. For instance, fats will combine with calcium and form an insoluble soap that is unable to be absorbed by the intestinal tract, as a matter of fact. If you put calcium in high quantity, it seems to be absorbed by the intestinal tract by diffusion, in other words there is no metabolic expenditure of energy, cellular energy to absorb this calcium, but under situations of low calcium intake there is an active expenditure of energy by these cells to absorb the calcium that is present within the gastrointestinal tract and take it into the body. So this whole thing is wrapped up again and you can't talk about one individual mineral as a point.

TEMPLE. An interesting case with calcium would be the female Red-tail that I used in the insemination work. She was obtained from a very naive farm boy in Iowa who had had the bird for nine years as a pet. He was not a falconer, just kept her as a pet; for nine years the bird never received casting. She received

nothing but beef heart and beef liver as the staple diet. That as we know is about the worst food you could put into a bird. When we got her at Cornell we only had her for about one month before she entered a reproductive cycle for us and she laid one egg normally. The next egg was laid without a shell. She went into a hypocalcemic condition similar to what poultry people call egg layer's cramp from chickens laying too many eggs and getting rid of too much calcium in it. What this bird did was wipe out her calcium reserve with one egg and the second egg was laid without a shell. In this case we administered calcium gluconate in the diet in large quantities and the third egg came normally and was fertile. As I say there is a good chance that early abuse in terms of a bad diet something like this is easily remedied.

CARLSON. Especially in terms of calcium, if you give them too much calcium during their growing period this can be very serious.

PLATT. You have mentioned the problem of calcium with young birds exposed to overdosage. What's that?

CARLSON. The bird gets used to excess amounts of calcium and basically the kidneys are just overworking and you end up with just an overloaded kidney. It is not going to be able to metabolize calcium later. There is a lot of necrosis as the veterinarians refer to it and gout and things of that nature that the bird would eventually succumb to. What we would like to do of course as soon as the bird is about ready to come into production, precede that for about a week or so with a diet that does have in the neighborhood of, for your type bird I would suppose about 2% calcium rather than the usual .8% that you are routinely feeding during the growing period.

Someone asked the question and I will repeat it for him. In terms of what could be deficient as far as a diet of meat or basically animal food is concerned? First as a poultry nutritionalist my experience is largely in the area of that type of an animal where they eat mostly grain or other byproducts of the vegetable kingdom and very little animal food. In fact today we probably have no food of animal origin in most of our poultry diet. But as far as meat protein is concerned there is one mineral that could perhaps be deficient and that is zinc. Normally when we feed high meat diets to poultry one of the things we look out about or worry about is the possibility of deficiency of zinc and this could be a factor of course, particularly in reproduction, in that it is required for sexual maturity, precocity and so on. So this is perhaps something that some of you might want to give some thought to. The natural diet where they get mostly meat just isn't going to carry a whole lot of this mineral for the animal. You may have to supplement with a supplement commercial type feed.

CRAWFORD. Is a deficiency of manganese important?

CARLSON. This is true if manganese or some of these trace minerals were in

the diet at rather marginal levels. You can increase the requirements for almost any of them by going excessive in terms of calcium-phosphorus ratio. If you have a good supply of manganese, zinc, and other trace minerals then you can vary your calcium levels quite widely without any great detriment. That is how we first discovered the importance of manganese. We put in extra calcium and phosphorus and sure enough the birds came down with sclerosis. When we put in 30 ppm of manganese, we don't have to worry about it.

CRAWFORD. What supplemental dose of manganese is used?

CARLSON. In the poultry case you put in a half ounce of manganese sulfate per ton of feed, 30 parts per million. Use a trace mineral salt that contains well about 1% manganese.

MARCUS. Did I hear you say you found that zinc was important for the reproductive process?

CARLSON. Yes. It's one of the more recent findings as far as mineral nutrition is concerned.

MARCUS. Where exactly is that concentrated?

CARLSON. In the ovary. The size of the yolk is greatly reduced in the case of a zinc deficiency. In fact if the animal is very markedly deficient you don't get any reproductive activity at all, even the sexual characteristics.

MARCUS. What I'm trying to find out is, what is a natural source of zinc for a raptor, a logical natural source for a natural supplement.

CARLSON. That's a real good question. Meat is very poor. Bone meal might have some. But zinc oxide, zinc sulfate, zinc salts of various sorts could be incorporated into a trace mineral mix to provide you with enough.

OLENDORFF. Does anybody have any ideas about egg binding, egg boundness in females. I understand this has been a problem.

HALLIWELL. Dr. McIntyre, has anybody ever called you about egg bound birds?

McINTYRE. No.

HALLIWELL. Has anybody else experienced this? Frankly, I don't feel the expert either; as far as I know it is inability to lay the egg. The ovum is released from the ovary, the white is secreted, the shell is formed, but the egg is not laid and that is as much as I know about it. I've never been consulted about the

malady.

WOLHUTER. Some of the literature of European zoos that are raising birds mentioned that birds that breed early in the season during cold temperature are more frequently egg bound, but whether it is indeed a function of temperature, I don't think has been proven, but this is one possibility.

LAWSON. Some work done in poultry indicates that it might also be due to water deprivation. You have to give adequate quantities of water.

HALLIWELL. Which would tie in with frozen water pans.

TEMPLE. I would like to make another point more closely related to breeding and water intake. I think anyone that has had any egg laying females has noted, and it is well-documented in poultry, that water intake goes up tremendously during egg production, because the bird is mobilizing a lot of water to go into the egg. It is very important that the bird has easy access to a lot of water when breeding.

COMMERCIAL BIRD-OF-PREY DIET

HALLIWELL. To my knowledge at the present time there are two commercially produced bird of prey diets and I am quite familiar with one of them. It is a product called Zu-Preem put out by Hill's Packing Company (Table 1). I don't get any commission, I am not peddling it. I'm just trying to use it as a

Table 1. Manufacturer's ingredient list and guaranteed analysis of Zu/Preem Bird of Prey Diet (Hill's Division Riviana Foods Inc., P.O. Box 148, Topeka, Kansas 66101).

Ingredients: Horse meat, horse meat byproducts, meat byproducts, chicken, fresh liver, ground corn, ground wheat, fish meal, dried whole egg, dicalcium phosphate, brewers dried yeast, iodized salt, choline chloride, Vitamin A palmitate, carotene, D-activated animal sterol, a-tocopherol, menadione, niacin, calcium pantothenate, thiamine, riboflavin, pyridoxine hydrochloride, folic acid, biotin, Vitamin B-12 supplement, ferrous carbonate, manganous oxide, zinc oxide, copper oxide, cobalt carbonate, magnesium oxide.

Guaranteed Analysis

Crude protein	min.	18.0%	Ash	max.	4.0%
Crude fat	min.	5.0%	Calcium	min.	0.4%
Crude fiber	max.	0.5%		max.	0.8%
Dry matter	min.	40.0%	Phosphorus	min.	0.3%
Moisture	max.	60.0%			

good example where we are falling down. The bird of prey diet put out by Hill's Packing Company has about 60% moisture which comes up again to the general area of 70% of body weight being water; protein, it's up about where the National Research Council recommends, 20%; fat, it has an adequate quantity; ash, remember in muscle meat ash is way down around 1%–here it is 4%. Vitamins–they do exist in specific quantities in this bird of prey diet and this is calculated with each batch that they mix up. And so we do have some idea what we are feeding the birds with this diet. Dave, would you like to talk about your programs at the Kansas City Zoo and any recommendations you have?

ALLEN. We have a pair of White-tailed Sea Eagles that have been on this diet for 23 months and they have reared progeny in 1970 and 1971. I would like to show you some pictures and add a few comments to what Dr. Halliwell said. This is the exhibit of the Kansas City Zoo where the pair of Sea Eagles is exhibited. This was an old mammal enclosure that was built by WPA in 1940 and these birds came to the zoo in 1964. We covered the bars with wire and the top with chain link. That is the pair on the nest. Now there are two nest frames and I turned in a breeding project questionnaire and there is a diagram in that BPIE No. 69 (*Raptor Research* 4(2):23-25, 1970). The birds chose the front nest which I believe is 15 or 18 feet from the public. And that is where they have nested and raised their two offspring. Here's a picture of the nest frame from the access door. The bottom is about six feet tall and the dimensions are in the BPIE. Both the 1970 female and 1971 male offspring were much larger than either of the parents and I think this is probably due to fat, lack of exercise, and I hope, superior diet; it worked very well. Now the back nest frame against the wall is the one they used mostly for perching. They can get back on the back edge under that ledge for shelter from the rain, sun, snow, it's the only protection they have.

The diet comes frozen, a five pound package, eight packages to the case. We feed two portions. A Kestrel portion is about the size of a ball we form and a larger portion for Golden Eagle. I did not know about the Nebraska product until today. I had heard they were working on it, but didn't know they had it out. The price is $12.85 per case and eight five-pound frozen chunks. Now a few falconers in the Kansas City area had a little difficulty in getting this product, but what we do is buy it in carload lots, store it in commercial cold storage and draw it off. Others can draw off it too, and they are charged for it. But this would have to be worked out with whoever uses Zu-Preem. You have to have a place to store it and freight on it will be quite expensive. I think you have to buy 40,000 pounds before they pay the freight. Birds have been on it for 23 months and they have produced two very large and healthy offspring. I would like to add that the manufacturer states that the pesticides DDT, DDD, and DDE are controlled during processing to .088 parts per million. Now I don't have any comparison figures today on what food of chickens, fish, horsemeat contain, but I know this will be considerably lower.

HALLIWELL. DDT in regular dog food and other meat byproducts varies, this ranges somewhere around 20 and 30 parts per million, so you can see that this is one-tenth.

ALLEN. Now the way it was explained to me is that they use a fish meal, human grade fish meal, and they have developed a process to remove these residues to this level, which I thought was significant considering we are talking about White-tailed Sea Eagles; their previous diet was fish, prepared fish.

To give you an example of what Dr. Halliwell mentioned, in mackerel, which was one of their favorites, the calcium to phosphorus ratio was 1 to 34. They were also fed smelt. We had a big problem with smelt to do with sea lions; now this is not other fish eating raptors, but I think it is significant in that smelt contains thiaminase and we had four deaths of sea lions: we had to give them supplementary injections of Vitamin B even to get them to eat. And further mackerel and smelt were used at the St. Louis Zoo and the high unsaturated fats caused death by steatitis in crocodilians. So our whole approach at Kansas City was to get not only the Sea Eagles but the rest of the birds off the fish. We have other carnivorous birds on the bird of prey diet and flamingos as well; we feel it's pretty important. You might be interested to know how we got the birds on this diet. It looks like hamburger, but it's not ground as finely and if the bird foots it or carries it, it sometimes falls apart, but Hill's is working on a chemical process to bind it together better.

HALLIWELL. Today I brought some samples of the product we're talking about, Zu Preem. It's ground up and it comes to you frozen. When you serve it and it thaws, it becomes almost mush and they have trouble carrying it. Hill's has now added a binder to this and I have brought samples of that packed in dry ice. I'll put out their present product and their new improved product on one of the tables in the back so you can examine them.

ALLEN. In introducing the birds to the product, we didn't really have any difficulties except with one Bateleur Eagle; she still hasn't accepted it as the sole ration. We accomplished it in various ways. Birds that had been kept on horse meat took it right away, the Sea Eagles accepted it in a week. We chopped fish with chunks of Zu-Preem; we even took the viscera out of rodents and stuffed it with Zu-Preem; it works. You'd be surprised how fast you can get them on it. We had one Kestrel on the diet for 16 months; it was killed by a predator. The other Kestrels in the zoo now have been on it about four months, so we feel we've greatly improved the diet because prior to this these birds were fed chunks of horse meat, typical zoo approach to raptors which we've already talked about. Growth is a factor of Zu-Preem that we haven't gotten into. Some young raptors were raised on freshly killed rats; as soon as they left the nest, we started transferring them over to Zu-Preem. We did have three downy Horned Owls brought in this year that we raised on Zu-Preem, and they were beautiful birds, had good color, appeared normal, and had no bone abnormalities. And

we also feed roughage once a week, rats and mice as supplement. Frank Kish, former Curator of Birds at Topeka, said the Golden Eagles that bred and raised offspring this year have also been maintained on this diet. And he says that the castings are normal without any supplementary feeding, but he didn't raise this eagle on Zu-Preem, he raised it on rats. We don't have anything much to say about the growth.

THACKER. Did I understand you correctly? You said you transferred some of your fish eating eagles from a fish diet onto the Zu-Preem diet. Have you found that the birds prefer this diet to a fish diet?

ALLEN. No, that's interesting. If you offer them any other food in connection with the Zu-Preem, they will eat the other food first. They will eat fish first, rats, not horse meat; they completely ignore horse meat.

McINTYRE. I can make one comment on this. I talked the salesman out of a case for a trial and the birds I've got won't eat it. I'm sure that I could get them on it in time, but it's real difficult to feed a bird in your fist with this Zu-Preem, I can tell you that.

HALLIWELL. I'm not about to suggest to any of you that this hamburger stuff works very well tied on the end of a lure swung around your head at the end of a ten foot cord. All your nearby friends will look like they have been through a hamburger melee. But I think all of us do put our birds up for the molt. The feathers and the other portions of the body will benefit from this diet. I think you cannot find a better diet to molt your birds out on.

ENDERSON. Is any casting formed with Zu-Preem?

ALLEN. Frank Kish of Topeka in the International Zoo Yearbook, Volume 10, states that castings in Golden Eagle were normal with a strict diet of Zu-Preem; now I'm quoting him. I can see that in Kansas City we feed once or twice a week whatever the schedule is, rats or mice.

VOICE. A normal casting would have feathers and things like this—what would be castings in Zu-Preem?

ALLEN. In Zu-Preem, there are whole chunks of bones and skin, but I have to confess I haven't tried analyzing the castings at all.

HUNTER. Now one of the things that you talked about was the dietary dry matter. I really don't understand why that is important if all you are going to do is increase the intake.

HALLIWELL. Dry matter does several things. Dry matter is a portion of this

casting. It is also methyl cellulose that is being utilized as a binder to hold this mush together. Binder can also be and in this particular case which is the only one I am familiar with, Zu-Preem is a fiber base that just provides extention to the stomach. Really, many of us could get along quite well on an astronaut diet of pills and a little bit of juice.

MENG. I am going to say something about casting. Some birds would be killed by giving them too much casting. A Sparrow Hawk, for example: if you feed them mice, they'll sometimes swallow all that fur and what does the fur do in the stomach? It just fills them up and they don't desire to eat any more. If you skin the mouse out, then they eat too much and they'll have that much more food in there. One thing that hasn't been brought out, if you feed this ground up material, I just don't feel right feeding my birds something like that; I want freshly killed pigeons, they're warm. I cut the head and crop off to avoid this trichomonad problem and the feet off, too. The birds just enjoy plucking the feathers off and eating this fresh material and I wouldn't subject my birds to these meat patties. I just can't see it. They have to have something like in the wild.

HALLIWELL. I certainly can sympathize with you and agree with you very well, but the point of this meeting as far as I'm concerned, is to improve captive breeding of raptors, and if this means feeding them horse manure that we can preserve this species, I'm going to be out there with a pitchfork!

STODDART. I agree. Whatever is possible to keep the birds alive so we can breed them, I'm not trying to cut any corners. What I want to know: has anyone fed this stuff to a Peregrine for three or four years? I have a Peregrine that is seven years old that was just given to me for breeding purposes and the bird was given Zu-Preem for two years, the last two years. That Peregrine does not have the feather quality, foot quality, or anything like it should be, and I've been pumping whole birds into it and the change is phenomenal.

MENG. Just one quick comment. When these birds feed on, say, the backbone of pigeons, they are constantly wearing their beak down, and there are many birds like my Peales' that I couldn't catch and cope their beaks off, it would upset them too much. By feeding fresh material like this where all the bones are there they have to pull their beaks are down. My Red-tail is 25 years old, I've never touched her beak, she's been living on pigeon heads for 25 years, all the pigeon heads I pull off.

GOBEN. I have something on the birds and their beaks growing and eating this pattie routine. I was feeding a lot of beef heart for a while, at one time I had a bird grow a long beak, and I threw in a rib of a deer; it was a Peregrine, and that thing just messed around with that thing until its beak wore down, it looked beautiful.

HALLIWELL. Thank you. Dave Allen, do you have anything to add to that?

ALLEN. Well, prior to 1968 in the zoo these birds, a lot of eagles, they had a lot of Golden and Bald Eagles then that were shot up, Fish and Wildlife Service brought in, were fed straight muscle horse meat. Now they survived for five to ten years without any casting material. So it occurred to me from a zoo standpoint, exactly what is the relationship to health of the bird and casting material? I've never understood this and we've gotten a lot of arguments about it. I am sure there is a relationship.

VOICE. Can we get an answer on casting? We have no definitive answer, we are all around the subject.

HALLIWELL. I think there is no definitive answer. I have no personal answer myself and I think from the wise rash of discussion, unless you've got scientific facts all you are talking about is hearsay and personal experience, and hearsay and personal experience hasn't been doing it in the past and it probably isn't going to do it in the future.

PATUXENT BIRD-OF-PREY DIET

PORTER. I'm here basically as an ecologist who has been involved in the breeding of American Kestrels, primarily. We do have a group of Peregrines that we are attempting to breed; these are tundra birds. I am from Patuxent Wildlife Research Center. We have done some work with Kestrels. We started a colony of Kestrels there in 1964 for the purpose of carrying out experiments with pesticides and we are still maintaining this colony. So far as their nutrition is concerned, we started out there, this was before my time, giving the birds ground beef which was primarily muscle, mixed with some liver and tongues and parts of beef supplemented with vitamins and minerals, and then we incorporated turkey breeder crumbled for the purpose of soaking up the excess fluids; these were ground up. Then the next diet that was used starting in 1966 was a horse meat diet supplemented with vitamins primarily with Vionate. The first year of reproduction in 1965 was fair. There were quite a number of the eggs hatch, and young were produced, but the adult birds ate a number of the young. They even captured some of the young after they had fledged, so there was something awry there somewhere. Then in 1966 with the horse meat diet there was little if any reproduction. There was also a foul-up, so to speak, in the behavior of the birds because in some the males were tethered after the females laid their third egg. The males were tethered because it was thought that in 1965 the males were responsible for the killing and eating of young birds and the destruction of eggs. This was before I arrived on the scene and the reproduction was nil. We had only a few birds hatch eggs.

In 1967 just prior to the nesting season, I placed the birds on a diet containing whole white rats, one third part, whole white hamsters or mice one third, and

one third part chicken necks. We removed the skins from the chicken necks to get rid of the excessive amounts of fat and I am not sure after learning what Dr. Halliwell has to say that this was a good idea. We included chicken heads, and we put one-sixth part. And we put them in a large cutter-mixer, Hobart cutter-mixer and cut them up into a very fine texture. Then we added to a 22 kilogram batch 75 grams of Vionate, well known vitamin supplement, and 126 grams of bone meal to give just in case the calcium-phosphorus content of the diet was insufficient. By utilizing this diet we obtained a reproductive success in the first year it was used equal to that which you would expect in wild Kestrels. And it turned out to be very successful. However, in the second year with this diet we ran into embryonic mortality in the colony, and we determined that at least part of the embryonic mortality was due to bacteria entering the egg and apparently killing the embryo. When the eggs are laid very early in the season they develop a film of condensed moisture around them and the bacteria enter from the nest box and apparently multiply in the egg and kill the embryo; however, there were a number of eggs that have not shown this. We have been unable to culture bacteria from eggs and we don't know just what to think about those. This situation has worsened in recent years. We have sterilized thoroughly the nest boxes prior to nesting seasons, put clean nest material in and still we get some embryonic mortality. This last year, 1971 breeding season, the embryonic mortality was quite bad. So after what Dr. Halliwell said I think that our diet, our ground diet may be suspect, I think it should be given a very thorough chemical analysis to determine whether there were deficiencies in the diet or not.

We have given our birds water, we have placed water trays on heaters throughout the winter so the water is available. Sometimes the birds had no water. At least they had water in the winter but we had no heater under the water pan and we viewed no detectable difference in their reproduction or in the birds.

We have been feeding our Peregrines this ground rodent and bird diet. Some birds have taken to it rather readily. One particular female, a large female that was captured off the beach at Assateague, very voraciously accepted it; within the first day it was accepted. And another female trapped the same day on the beach took literally weeks to accept this diet. We now feed our Peregrines white rats during the non-breeding season supplemented with an occasional Coturnix Quail and an occasional Mallard duck. We do not feed them the Kestrel diet. I don't know just what to say about the ground Kestrel diet. It has been very successful in the past but as I have indicated I believe that it is very much in need of a good chemical analysis to determine just exactly what it has in it, what might be missing to cause our unexplained embryonic mortality. It may be due to this factor. We have tried Vionate. I think Vionate is an excellent diet supplement. We got good hatchability with Kestrels using Vionate. The shells of the egg appeared to be in somewhat better condition than with our regular Kestrel diet; this is just from cursory observation. However, after hatching we have had problems. I shall leave this to the final discussion on Health and Nutrition of the Young.

OTHER FOOD FOR CAPTIVE RAPTORS

McINTYRE. I suppose you all know that I'm from the Air Force Academy. When I took over this job they were feeding these birds nothing but frozen beef hearts. Well, me being a neophyte in the falconry business, I couldn't see feeding these birds beef heart as a complete diet. Every once in a while, maybe once a year, they'd go out and get some pigeons and feed these birds pigeons. Well, a month after I took over, I threw out 400 pounds of frozen beef heart. You know, I can do this, being a veterinarian; I declared them unfit for human consumption and threw them out. At first I started using quail, Coturnix Quail. Then the guy I was buying the Coturnix Quail from got outrageous in his price and we started using our own chickens. We'd get day-old chickens and raise them to three weeks. The feed we were putting into them, the only non-medicated feed that you can put into a chicken, I think, is game bird feed. Actually the medicated feed has about 3% Auromyacin in it and I cannot see that this is going to hurt any bird of prey. I also used a water soluble multi-vitamin, it's called Head Start, and put this in the water of the chicks. This way I don't have to worry about giving my hawks multivitamins. During the winter time, since I have access to the hospital at the Academy, I get a bottle of multivitamins and shove a tablet down the birds every other day. Of course, I noted a great improvement in the condition of the birds and the sheen of the feathers and so forth, so I thought that we were on the right gimmick, and we've had some birds now that we've had for six, seven, eight years that have been on this chicken diet almost exclusively. Occasionally we feed them some venison that we get off a road kill at the Academy. Of the breeders that we have, a pair of anatums, the tiercel we had was in lousy shape when we got him. He was supposed to have been five years of age. His feet and cere were completely white; he couldn't jump off the ground to a block perch. Two weeks after we had him on a strictly chicken diet, and we fed the whole chicken, just took nothing off. We have learned now to cut the feet off because the Peregrines particularly won't eat the shank of the legs and this saves the cadets from going around picking them up. Now we got eight eggs out of the Peregrine last year in two different clutches. The tiercel did not have much to do with it, but I think it was because he was in such lousy shape when we got him. I am looking for better signs this year, hopefully, than we had last year, because he is in real good shape. Now we fly him on a string, and we jump him straight up, and he's in pretty good shape. And he is real tame, you can put him in your coat pocket, carry him any place you want to. Sometimes we take him to football games and we never tie him up in a hotel room. Of course this shakes a lot of people up—they walk in there and there is a Peregrine sitting on the back of a chair. I think, I hope this is an adequate diet. After looking at these figures Bill gave, I am not too sure. In the breeding pen of course we keep a bath of water which was a wading pool; we try to keep it full of water all the time. Fortunately we're lucky we have water available; the big problem is that it freezes in the wintertime. So this is about all I have on the nutrition of these birds.

HUNTER. What would be the cost? Would the cost be prohibitive to do a comprehensive assay on four week old chick? And wouldn't it be fruitful to do so?

HALLIWELL. I think it probably would be fruitful to do so. I don't know whether I am capable of doing it or not, but I will certainly check into it and see.

TEMPLE. We have the nutrition people at Cornell doing an analysis of day old chicks, horse meat, and the various things that we are feeding the birds. They are doing one at a time. They started on the day old chicks and the four week old chicks. This information should be available soon.

THACKER. I just want to make a comment on thiamine deficiency in Peregrine Falcons. Bill was saying that Prescott Ward diagnosed it in a Peregrine Falcon last year which was in *AVMA Journal.* Near Ohio State there is a bird sanctuary. It's run by one of the Audubon groups and based on Prescott Ward's article all of the birds fed there are fed on chicks; this is cockerels up to 12 days old. They get them from a local dealer, kill them and feed direct. And these birds have been on these chicks now for at least a year and a quarter to a year and a half. And in the last four months we have had two Great Horned Owls, a Red-tail, a Red-shoulder, and a Prairie Falcon all exhibiting signs of thiamine deficiency. That is one point I wanted to bring up about chicks.

SWARTZ. I have my own conviction about snowshoe hares—they're poor food. Would you comment on beef heart?

McINTYRE. Beef heart of course, I think we're all agreed, but maybe not, basically is low in calcium and phosphorus. Of course, with beef heart you get no castings at all. I think you can supplement an adequate diet with this occasionally, an adequate diet of pigeons, chickens, maybe rats. I'm sure that people who feed pigeons regularly feel that this is the best diet. And I can't argue with them. The only argument I've got is that you always have to worry about trichomonas or frounce. And since people don't want to disturb breeding pairs particularly you are taking a chance to lose a bird. Of course I am a great believer in casting material; this is why we have gone strictly to the chicken. And it's a whole chicken, feathers and all, and they get good castings every day. I would stay away from wild birds because I don't know how much pesticide they may have in them: Starlings and so forth. Dick Graham, I think, had some chickens analyzed that he is raising. And three of us in the Colorado Springs area have chickens from the same hatchery. I forget now, but I think he said the highest part pesticides was in the liver, about .03 parts per million. Is that right?

GRAHAM. Yes, that was the highest of the whole business.

GALICZ. For the last few years I have been experimenting by feeding strictly rabbit heads. These are strictly fresh rabbit heads acquired fresh at the butcher's three times a week and each pair of Peregrine receives three heads per day. They appear healthy, they have extremely good egg production both last year and particularly this year. One pair had as many as three clutches and incubated all three, but there is a problem of fertility. Now what is the answer, this is my question.

HALLIWELL. I won't try to pick out specific factors, but I certainly think you are not feeding a whole animal diet. One thing you are missing and you haven't seen it in these birds yet, maybe they are picking it up someplace else. Dr. Prescott Ward at Edgewood Arsenal in Maryland a year ago diagnosed a case of thiamine deficiency in a Peregrine Falcon, most of you are familiar with the work. So far as we can tell, the only place that thiamine is found in the natural diet of birds of prey is in the intestinal tract, in the ingesta of the intestinal tract, so I would say you are missing this. I frankly think you are missing quite a bit.

GALICZ. They are producing eggs, and they are beautiful eggs; the birds appear healthy.

HALLIWELL. These eggs, have you checked them? Have any of them been fertilized?

GALICZ. Last year there was a possibility that one hatched but it is not conclusive. The chick disappeared, that was the only case but it is not conclusive. It appeared to be there, but four days later when I actually checked back the other three eggs were there and they were rotten, they were not fertile.

HALLIWELL. My comment to you would be to switch diets and I don't know where you're going to switch to.

GALICZ. My reason for feeding the rabbit heads was because I was assured they were reasonably free from various pesticides; these people were feeding very carefully. The only other thing I did use was Vitamin E at one period after they finished setting and 14 days after nesting they immediately laid again. Now whether it is the Vitamin E that prompted the laying so quickly after incubating, I don't know.

MENG. I feed my birds pigeons; I take the two breasts off and then give them the backs and the intestines and all the gonads of mature pigeons. They seem to get the hormones from the gonads they feed on. So if you could do that in addition to the rabbits perhaps that could be the answer.

GALICZ. I'll give it a try next season.

HALLIWELL. Why not just combine, feed two or three varied diets.

NELSON. I have a possible answer to George Galicz's question, and Dr. Meng might have some suggestions or ideas here. In birds in the wild the female for several weeks prior to egg laying doesn't get any heads. The male eats the heads, brings the rest to the female in courtship feeding activities. The female, while she is laying and right through apparently until the chicks are a couple weeks old, doesn't get any heads or virtually none, although there may be some. Now Dr. Meng might have some ideas here and others who have fed whole prey items. Do the birds select certain parts from their kill? I think they do and certainly if you could arrange it to feed them whole pigeons the birds are going to medicate themselves. They've done this for millions of years.

SWARTZ. I would like to comment on the point of varied diet and also to parasites; I've been playing a trick lately. Skip Walker is our stock feeder in maintaining our mouse colony, when they get to a certain size I take over the feed lot operation and feed them up on laboratory chow, then take them off of the laboratory diet and put them on pure carrot. The skin then turns yellow in just three days. This may serve to flush some of the bad things out of them in this way. The Merlins for example get one of these mice every day; this does produce a very lovely yellow fat, interesting yellow ceres. The feet are also yellow; it's been, so far, very satisfying and solves this intestinal problem, too.

HALLIWELL. I would like to have Mr. Kent Carnie talk about his birds that have gone on a more adequate diet, and you can even see the difference in the tail feathers.

CARNIE. I was flying an intermewed passage European Goshawk. She had been fed on a diet in essense of what she caught, jackrabbits, all last winter. She took straight muscle plus heart, that was it. She seemed healthy, she flew extremely well, the diet was fine, her appetite was fine, but midsummer she came down with what I would have said was frounce ten years ago. However, there were no trichomonads. She might have had spots in the lungs, it might have been aspergillosis, but it seems very possibly that from this straight meat muscle diet it might well have been the vitamin deficiency, something that Dr. Halliwell published about in *Hawk Chalk;* it sounded like Vitamin A. Anyway we tested for aspergillosis, we treated for frounce, we treated for vitamin deficiency. At the same time with the vitamin deficiency, I gave her one-a-day vitamin tablets, first daily, then every other day, then twice a week. I changed her chow from straight jackrabbit muscle to an entire pigeon cut up in pieces which unfortunately at that time had to be forced down her throat. This bird went entirely off her feed; she had to be force fed for nine days straight. She went from 50 to 44 ounces and things looked bleak. Nine days straight, she finally bottomed out at 44 and began to perk up. Up to that time incidentally her feet were pale gray and very, very scaly and very dry in contrast to the yellow

waxy feet of Al Nye's Gos for example. He had her on a diet I'm not familiar with, I think young chicks. Incidentally I tried the chick route with this bird, she just won't have it. Prior to this disease she had shown a perfectly normal molt except that she had only dropped her decks and she dropped nothing else in the train. With the onset of the disease and the change in diet, she began to snap out of it, she dropped her train. You can now look at this bird's train and see her decks in comparison with the brand new feathers. They are as different as night and day. The feathers are drastically different in color, in quality, in brittleness and this thing speaks to a natural diet to me. It is my fault she got into this condition. It is because of Raptor Research Pathology Committee that she is alive today. It surely shows by looking at this one bird's train the visible evidence of the different environment.

HALLIWELL. Most of the people raising birds of prey or keeping them in captivity have been feeding a somewhat jury-rigged diet containing either chicken parts or chicken wings or something like that and trying to supplement the diet with products, usually veterinary products such as Vionate and diet supplements. And I wondered if you would discuss for a moment the rationale of trying to supplement a basically inadequate diet by adding to it these supplements. In other words what is your opinion in this direction? My personal approach is to try to put into the diet to begin with everything you need, in other words to try to provide in the diet by what you are feeding rather than supplement, let's say, horse meat with large amounts of Vitamin E, Vitamin A, minerals, and so on down the line. Do you understand?

CARLSON. A number of years ago we used to do what we call a free choice feeding along with our poultry feeds and we put several things out there for the birds to pick at. We found that most of them might do a fair job, but there were always those few that were just too gluttonous in eating all grain or all mash or all this or that and wouldn't really balance their diet and so we came to the conclusion that it was necessary to put everything in one meal and I think that is what you were getting at. And so I think where you have considerable investment that this is the way I would go. I would try to formulate a complete ration and expect the animal to get that. Of course all of one thing—they may not like it, it's not very much variety, but we have found in commercial poultry production that that is what gives us the return.

CAMPBELL. Would you care to comment on egg yolk as a source of vitamin, trace minerals, and supplementary food for raptors?

CARLSON. As a poultry nutritionalist I would have to say that egg yolk is the perfect food. It does contain all the essentials at least for the growth of that embryo throughout that period that it is in the shell and even for a few days afterward. Generally there are pretty fair quantities, so I would say that egg yolk ought to be a good supplement.

HALLIWELL. Quite a few people have been feeding day old cockerels to their adult raptorial birds. Would you comment on what you think the nutritional value is of day old cockerels?

CARLSON. They still have a good amount of egg yolk in them. Then again you are getting about everything that was in the egg to begin with except the loss of a little oxygen and maybe some other things that volatilize. It should be a pretty fair diet.

HALLIWELL. Do you think that this would be a nutritionally staple diet again considering carbohydrates, fats, proteins, minerals, vitamins, to maintain the healthy bird?

CARLSON. It should be.

VOICE. Isn't a four week old chick more nutritional source of food than a day old chick?

CARLSON. I would say that a day old chick would be better than a four week one. The only reason I would say that the other bird is not quite as good is that we have diluted it perhaps with nutrients that your raptor is not going to need. Zinc, for example. You don't build up much zinc in that bird and yet the day old chick probably contains a lot more in parts per million.

HALLIWELL. What would you think of the mineral contents of day old chicks? What I'm really trying to say is that this chick had to utilize metabolically many of the nutrients that were in that egg the day it was laid in order to create a baby chick at the time of hatching. What is the relationship of this to a chicken that has grown to four or so odd weeks on an adequate diet?

CARLSON. Well, there is one thing that the day old chick would not have and that is calcium and phosphorus. Even though the shell is almost 100% calcium carbonate, not much of it gets into the chicken itself. The bones are practically all protein; there is very little calcified tissue there. Certainly the older bird would be much better for the massive minerals, in other words calcium, phosphorus and so on. Other than that I think you would be better off with the day old chick.

SHERROD. It seems to me that since they naturally prey on older birds, it would seem natural to use other than day old chicks.

CARLSON. This is true. Certainly the older bird is probably going to be a pretty good diet. Maybe as good as the bird needs.

EBERLY. I read one report by a gentleman, I believe in Europe, who had

success breeding owls and he switched his diet over to cockerels, probably around five weeks old, and he did not have success that year. He thought maybe it was because he had used medicated pre-starter for the chicks. What do you think of that?

McINTYRE. I really don't know, but I don't see the logic behind this. The medication in this medicated feed is so small, it's 3% aureomyacin and you try to correlate this and say well there probably wouldn't be so many humans on earth if this had something to do with fertility, because there are a lot of people that get shot with antibiotics today and a lot of people take it orally without a prescription or with a prescription and this is the only basis I know, I really don't know.

EBERLY. Is that all that's in it, aureomyacin?

McINTYRE. That's all that's in it.

HALLIWELL. If you have something else to add on medicated feed we'll listen to you.

FYFE. I was under the understanding that some of the things that are going into chicken starter and turkey starter include arsenic in very small quantities, and I wonder if this would have any effect or should be of a concern as far as the next step up in birds of prey which would concentrate something like this.

HALLIWELL. Yes, everything you have said is true. My only answer is they are dumping just as much in the rivers and on the fields and the prey species contain some also. Beyond this I am unwilling or unable to comment.

SMYLIE. What I would like to know is, in this starter feed are coccidiostats in there? Are there any hormones or anything else that could be carried through to show changes in the raptors? Also what is the amount of DDT found in commercial chicken, etc., that is available at the grocery store now?

CARLSON. Well, as far as the chick starter being carried over to the raptor, I don't believe there is anything there that you need to worry about as far as hormones are concerned. We don't add hormones at the present time. We do have antibiotics and coccidiostat to cut down on coccidiosis. But at the level it is used and by the time it goes through the bird I'm sure that this would not interfere with the bird that you are concerned with. As far as the amount of DDT and other chlorinated hydrocarbons in poultry, undoubtedly there is some but Food and Drug is doing a pretty good job in terms of monitoring this and I don't think it's going to hurt you as much to eat that bird as it hurt the bird in the beginning. In other words we find that avian species are much more susceptible to chlorinated hydrocarbons than people are. Of course that brings another

question—do we get enough in them to hurt your bird? That's entirely another subject. At the present time under conditions where we do have control over our animals I don't believe this is a problem. If, for example, you have your aviary close to where they are burning some transformers, I would be a little bit concerned about PCB's and things.

GALICZ. I understand that stilbesterol is used in some cases to promote rapid growth in poultry. Now if such poultry was fed to the hawks, would this cause sterility?

CARLSON. If you fed nothing but livers I suspect after a few years this might be a problem, but normally I don't think so. We used to be able to inject a pellet into the bird but this was prohibited about 15 years ago. Now the only way we can get into a bird is through the diet or through the drinking water and then in very minute quantities. I don't think it would be a problem. Then you might be concerned with feeding a lot of cow liver or something where you're getting a real potent supply.

TEMPLE. In this regard, too, all of the steroid hormones including diethyl stilbesterol in the chickens that you would be feeding to your hawk is fairly rapidly broken down. The residues that would be in birds will probably be so small, unless you were giving a massive dose I wouldn't worry about it.

GALICZ. The reason I was asking that is, at one stage I happened to be engaged in commercial mink farming and some years back in Canada we did have some serious problems with lack of production in mink directly due to feeding chicken.

CARLSON. But you fed them the whole head and that head had a pellet in the back of the neck so they got a real slug of it.